NASA EARTH SCIENCE & APPLICATIONS DIVISION

Earth Science and Applications Division

Shelby Tilford, Director

A COMPREHENSIVE MISSION TO PLANET EARTH

Woods Hole Space Science and Applications Advisory Committee Planning Workshop

July 29, 1991

ESAD

A Comprehensive Mission to Planet Earth

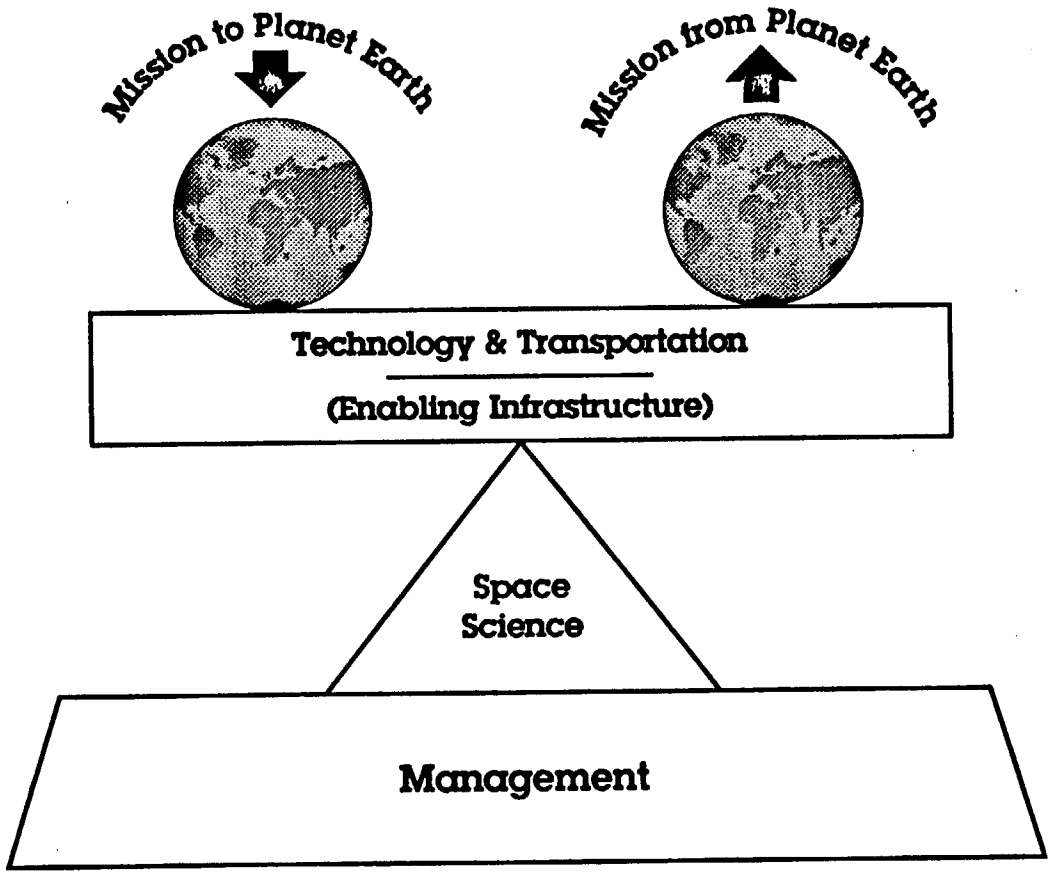
A major national and international initiative is needed to seek new solutions for ozone depletion and global warming and acid rain. And this initiative -- Mission to Planet Earth -- is a critical part of our space program.

President George Bush, July 20, 1989

... it is the Mission to Planet Earth which connotes some degree of urgency...This effort will provide us with a much better understanding of our environment, how we may be affecting it, and what might be done to restore it.

Augustine Committee Report, December 1990

A Balanced Space Program for America



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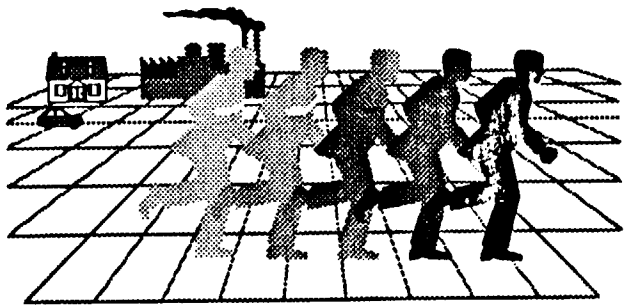
Problem: Earth System is Changing

Increasing greenhouse gases
Decreasing levels of stratospheric ozone
Acid rain
Deforestation
Decreasing biodiversity



There are strong indications that human activity accelerates the rate of change

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The Earth System is Changing

Problem	Fact
Increasing greenhouse gases	5,000 TgC of CO_2 pumped into the atmosphere each year
Decreasing levels of stratospheric ozone	5% per year increase in atmospheric concentrations of chlorofluorocarbons
Decreasing biodiversity	20 to 25% of existing tropical species extinct by 2015
Deforestation	11.3 million hectares of mature forest leveled annually
Burgeoning human population	Global population of 5,750 million by the year 2000

Strong indications that human activity accelerates the rate of change

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What We Do Not Know

The rate of global change

How fast?

The magnitude of global change

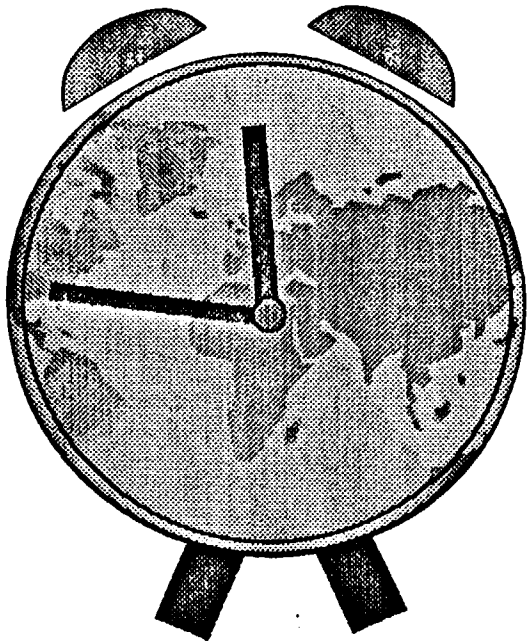
How much?

The timing of global change

How soon?

The local and regional impact

What about me?



At present, scientists are unable to accurately predict the consequences of human actions on the future habitability of the Earth

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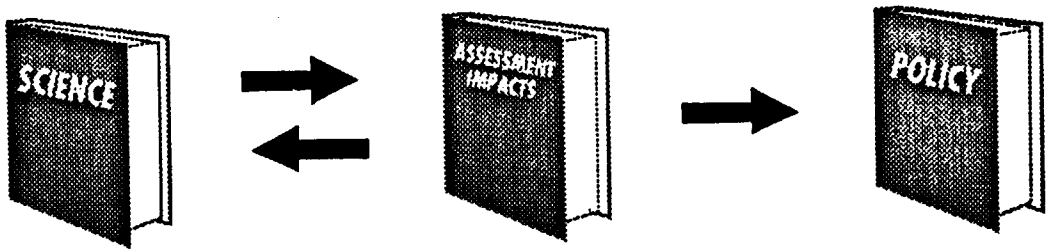
Global Change Research Program Goal

Establish the scientific basis for national and international policymaking relating to natural and human-induced changes in the global Earth system

Global Change

What Do We Know? Where Are We Going?



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Develop integrated, conceptual, and predictive Earth system models on global and regional scales

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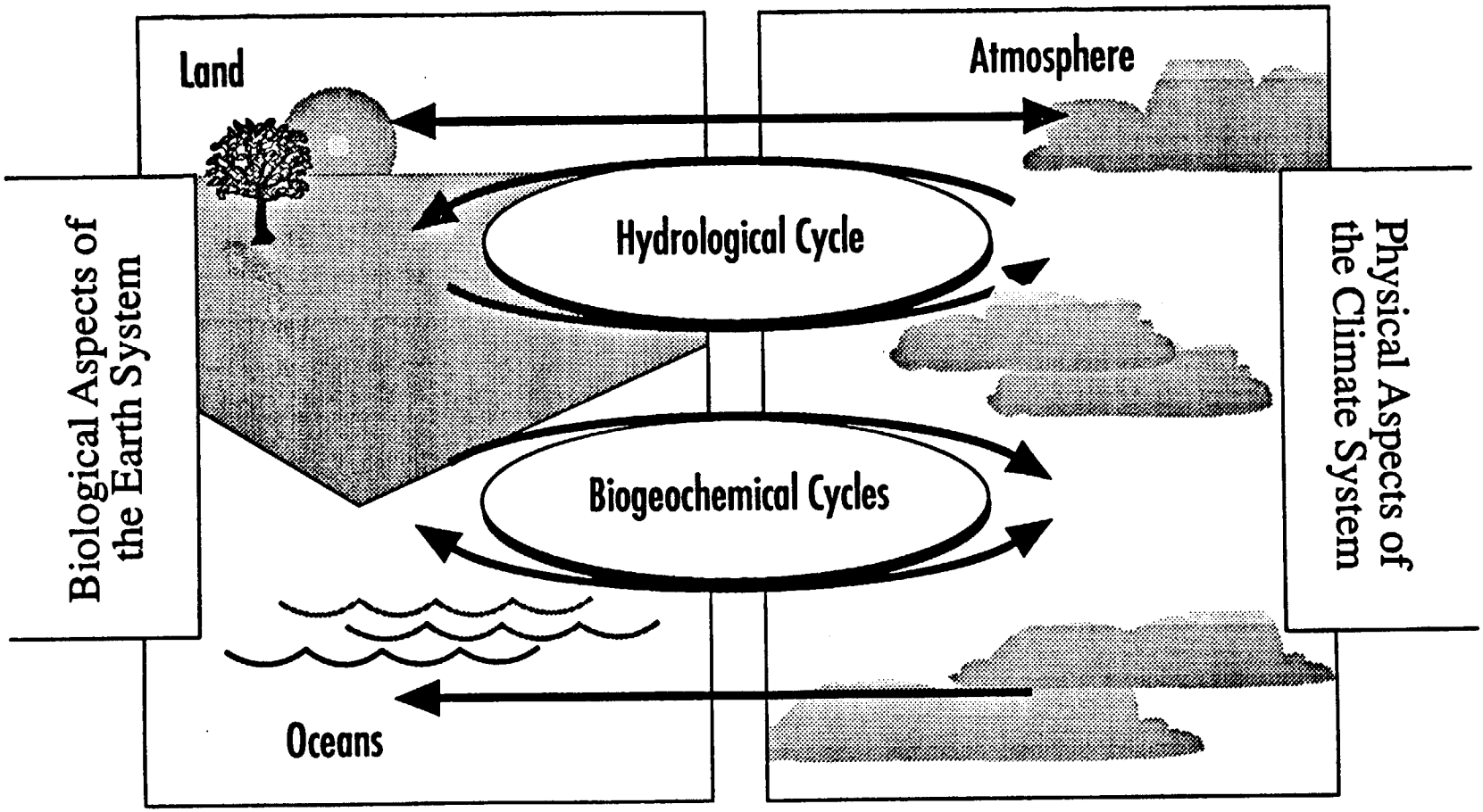

International Geosphere-Biosphere Programme

World Climate Research Programme

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Key Areas of Scientific Uncertainty in Global Change Prediction

Role of greenhouse gases

Role of clouds

Role of oceans

Role of polar ice sheets

Land surface hydrology

Ecosystems response

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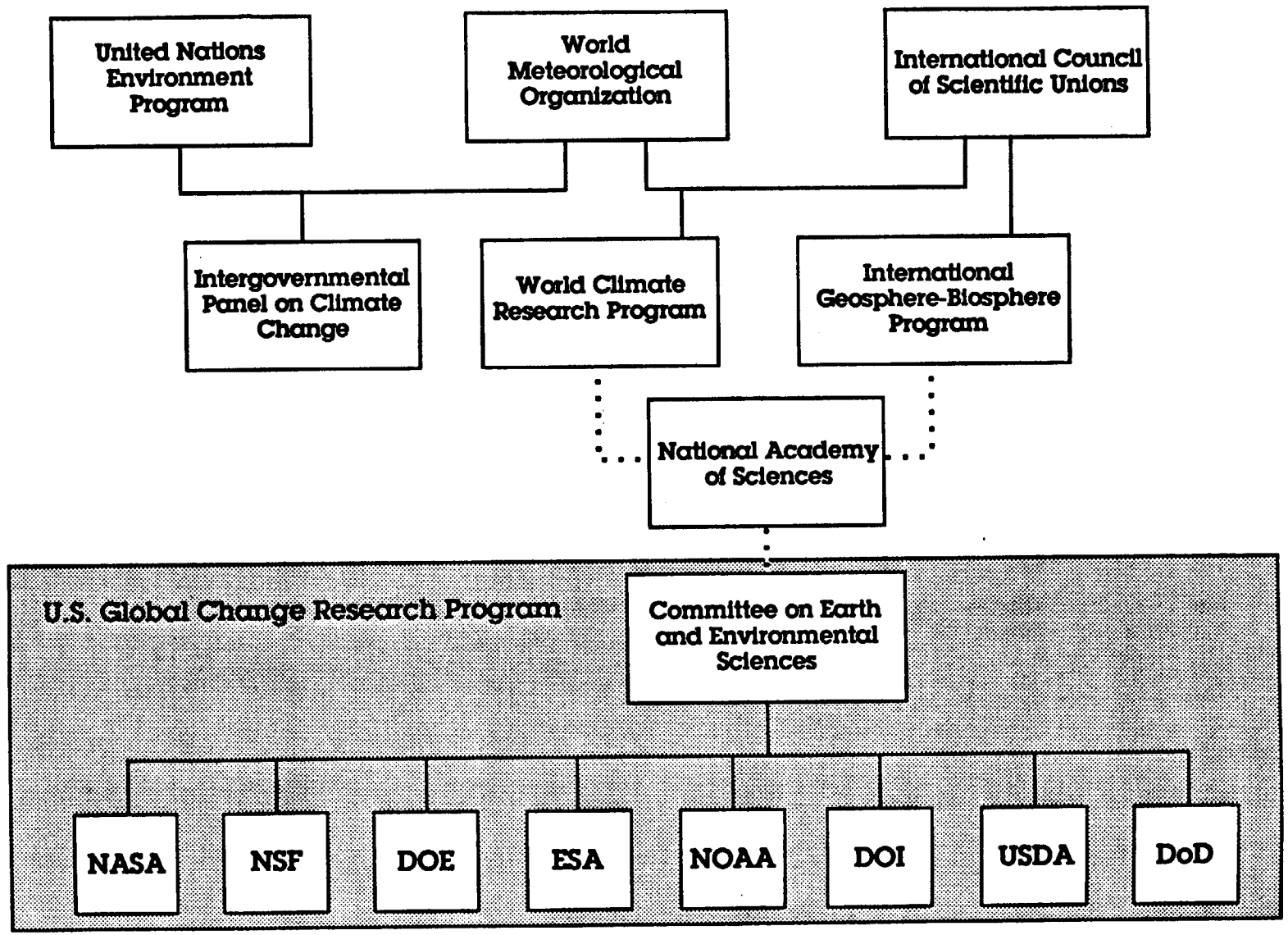

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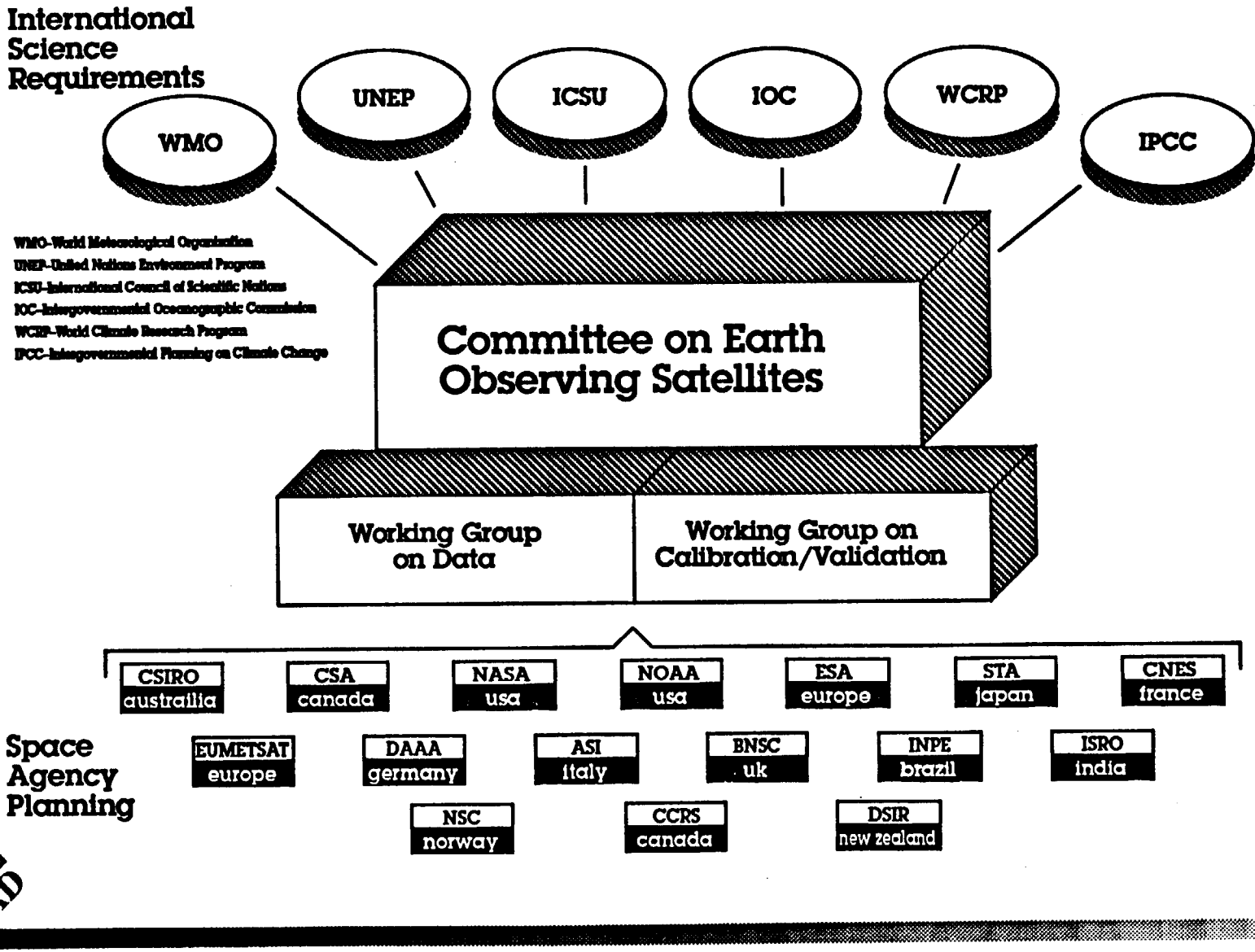
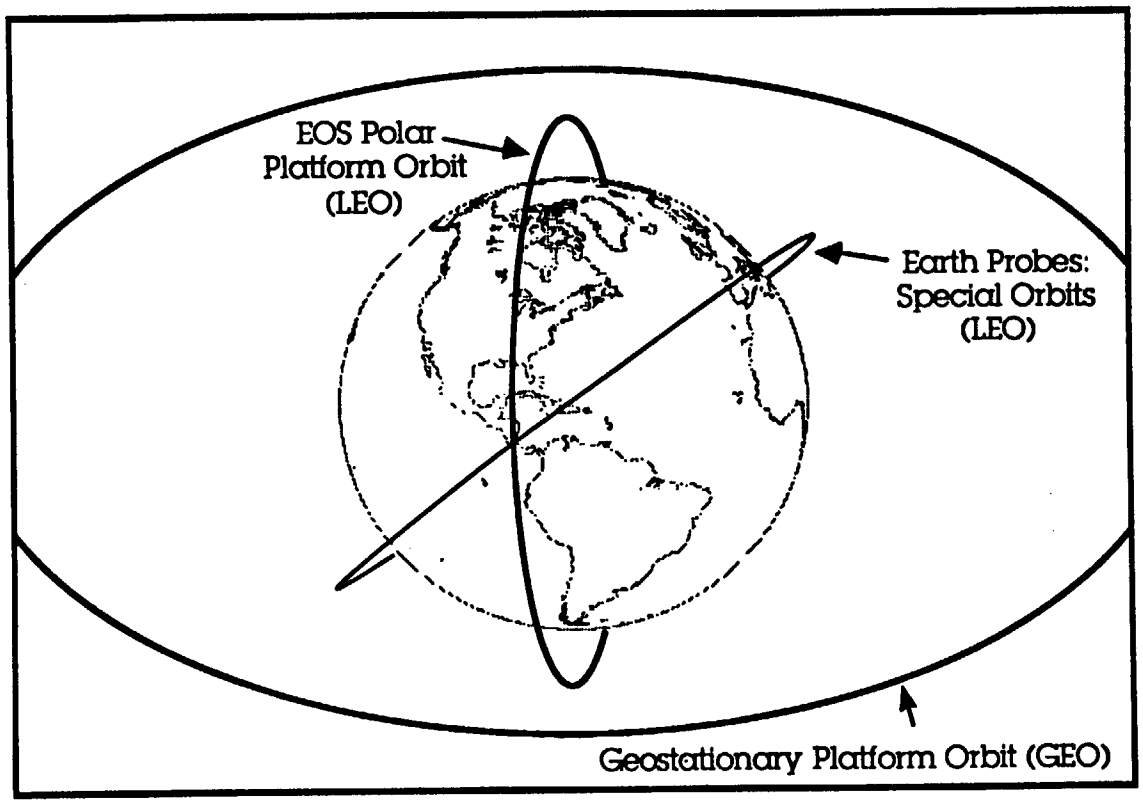
International Coordination of Mission to Planet Earth



Comprehensive Understanding Requires Comprehensive Space Observations



Mission To Planet Earth
Complementary Space Observations

Sun-synchronous polar orbits

Global coverage: Fixed crossing times
Repeat sampling at intervals of hours to weeks
Laser, radar, and passive remote sensing

Low-inclination, low-altitude orbits

Tropical coverage: All local times
Repeat sampling at intervals of hours to weeks
Laser, radar, and passive remote sensing

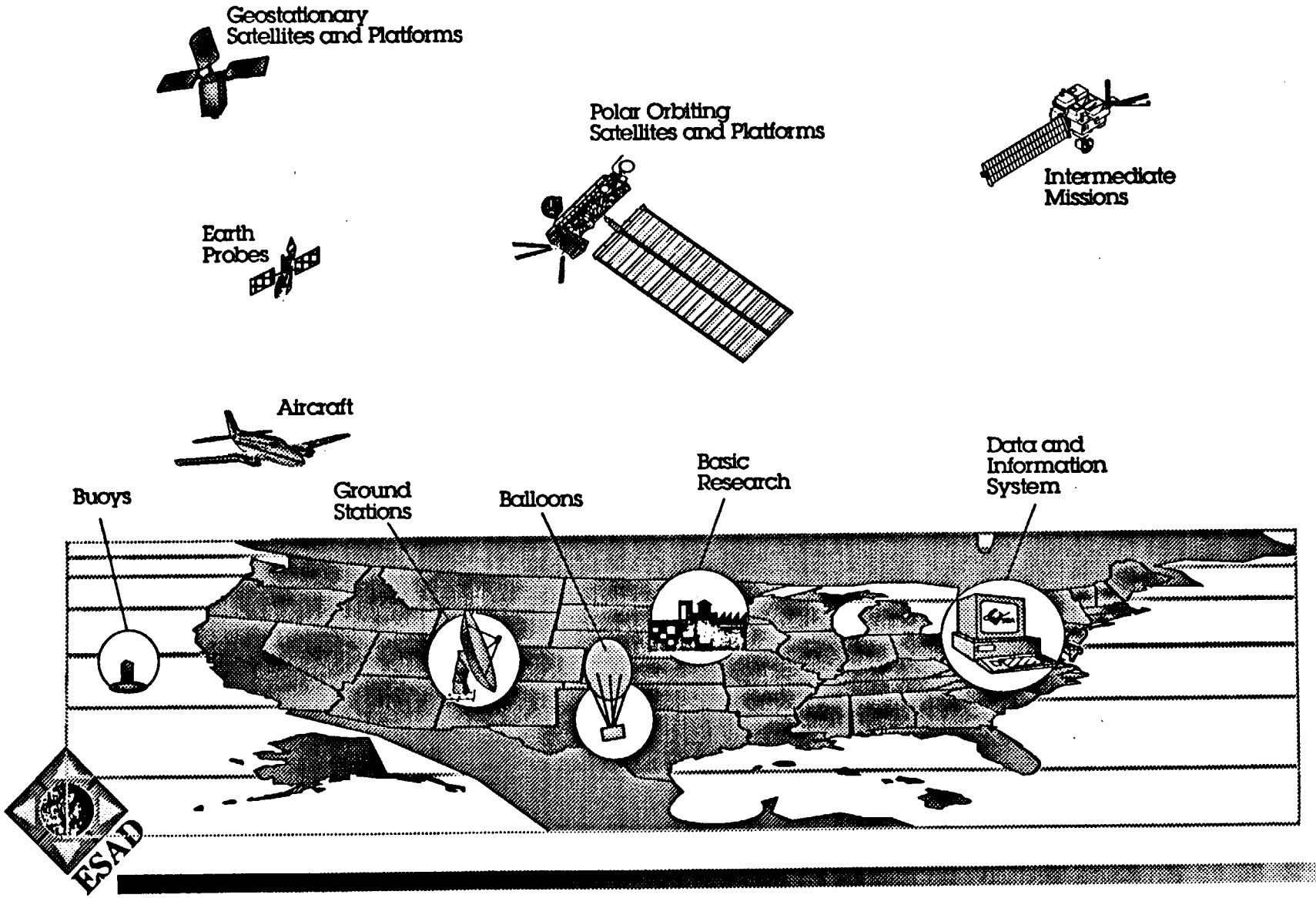
Geostationary orbits

Regional views or full Earth disk
Continuous coverage of selected areas
Passive remote sensing

Ground Measurements

Calibration and validation of satellite observations
Local and regional process studies

Mission to Planet Earth



Approved Missions in ESAD's Base and MTPE Programs

	Base Missions	Launch Date
ATLAS	Atmospheric Laboratory for Applications and Science-1	April 1992
	Atmospheric Laboratory for Applications and Science-2	April 199
	Atmospheric Laboratory for Applications and Science-3	January 1994
	Atmospheric Laboratory for Applications and Science-4	January 1995
	Atmospheric Laboratory for Applications and Science-5	January 1996
	Atmospheric Laboratory for Applications and Science-6	January 1997
LAGEOS-II	Laser Geodynamics Satellite-II	September 1992
SRL	Shuttle Research Laboratory-1 (with SIR-C and X-SAR) (Germany)	September 1993
	Shuttle Research Laboratory-2 (with SIR-C and X-SAR) (Germany)	September 1994
	Shuttle Research Laboratory-3 (with SIR-C and X-SAR) (Germany)	January 1996
SBUV	Solar Backscatter Ultraviolet/Version-2 (on NOAA-I)	December 1991
	Solar Backscatter Ultraviolet/Version-2 (on NOAA-K)	July 1994
	Solar Backscatter Ultravioltet/Version-2 (on NOAA-M)	February 1997
SeaWIFS	Sea Wild Field Sensor (data purchase only)	August 1993
UARS	Upper Atmosphere Research Satellite	September 1991
TOPEX/Poseidon	Ocean Topography Experiment/Poseidon (France)	July 1992
	MTPE approved	
Earth Probes		
TOMS	Total Ozone Mapping Spectrometer/Meteor-3 (USSR)	August 1991
	Total Ozone Mapping Spectrometer/Scout	September 1993
	Total Ozone Mapping Spectrometer/ADEOS (Japan)	February 1995
NSCAT	NASA Scatterometer/ADEOS (Japan)	February 1995
TRMM	Tropical Rainfall Monitoring Mission (Japan)	February 1997
EOS-A Series	Earth Observing System-A1/A2/A3	December 1998 (A1)
EOS-B Series	Earth Observing System-A1/A2/A3	2001 (B1)

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Proposed Missions in ESAD's MTPE Program

	Earth Probes (level-of-effort)	Launch Date
AMAG	ARISTOTELES Magnetic Field Experiment	1997
GTM	Global Topography Mission	1999
	Others TBD	
	Intermediate Missions	
EOS SAR	EOS Synthetic Aperture Radar	2000
	Major Missions	
GEO	Geostationary Earth Observatory	2003

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Airborne Science and Applications Program

Present Program includes operation of a single DC-8 aircraft. This aircraft supports major segments of the Space Science and Applications program dealing with the Earth, the oceans, and the atmosphere. Recently completed or planned program support missions:

Solid Earth Science, Biogeochemistry & Geophysics, Ecosystem Dynamics & Biogeochemical Cycles Programs - Observational campaigns utilizing the Airborne Synthetic Aperture Radar (SAR); Multiple Airborne Campaign - Europe

Atmospheric Chemistry Program - Studies of Polar Stratospheric Chemistry and Ozone Depletion through intensive Airborne observation campaigns

Radiation, Dynamics & Hydrology Program - Global Aerosol Backscatter Experiment (GLOBE)

Mission To Planet Earth Support - Ground Truth Observations for EOS Precursor and Earth Probe Missions

Because of its long range and high altitude capabilities and the need for these characteristics by the Earth sciences research community, the NASA DC-8 is over subscribed

Typically, demand exceeds availability. Downtime due to integration and deintegration of the AIRSAR instrument results in loss of available flying time

Demand and criticality of this resource to the NASA and US Global Change Research Programs justify the acquisition of a second DC-8 to dedicate to the AIRSAR instrument

The Earth Probes Program—Mission Definition

Definition of all missions based on science measurement requirements identified by the National Academy of Sciences (NAS)

A Strategy for Earth Science from Space in the 1980's and 1990's, part 1: Solid Earth and Oceans, National Academy Press, 1982.

A Strategy for Earth Science from Space in the 1980's and 1990's, part 2: Atmosphere and Interactions with the Solid Earth and Oceans, National Academy Press, 1985.

Strategy for Earth Explorers in Global Earth Sciences, National Academy Press, 1988.

Space Science in the Twenty-First Century, Imperatives for the Decades 1995 to 2015, National Academy Press, 1988.

The U.S. Global Change Research Program, An Assessment of the FY 1991 Plans, National Academy Press, 1990.

Research Strategies for the U.S. Global Change Research Program, National Academy Press, 1990.

Assessment of Satellite Earth Observation Programs 1991, Committee on Earth Studies, National Academy Press, 1991.

The Earth Probes Program

Approved

- Total Ozone Mapping Spectrometer (TOMS)/Meteor—1991
- TOMS/Free Flyer—1993
- TOMS/ADEOS—1995
- NASA Scatterometer (NSCAT)/ADEOS—1995
- Tropical Rainfall Measuring Mission (TRMM)—1997

Proposed

- Applications and Research Involving Space Technologies Observing the Earth's Field from Low Orbiting Satellite (ARISTOTELES)
- Global Topography Mission (GTM)

Future (Not in Order of Priority)

- Geopotential Research Mission
- Measurement of Air Pollution from Satellites
- Mesoscale Research Explorer
- Magnetic Field Experiment
- Rain Mapping Mission
- Earth Radiation Budget Mission
- Solar Input Mission
- Volcano Mapping Mission
- Other complementary missions

ARISTOTELES Mission

ARISTOTELES = Applications and Research Involving Space Technologies Observing The Earth's field from Low Earth orbiting Satellite

Scientific objectives contribute to the understanding of:

- The dynamics of the Earth's core and origin of the magnetic field
- The composition and dynamics of the mantle
- The structure and dynamics of the continental crust
- Improved ocean circulation models through high resolution ocean geoid

ARISTOTELES is a joint NASA/ESA mission

- NASA provides: scalar and vector magnetometers, onboard Global Positioning Satellite (GPS) receiver, and tracking
- ESA provides: gravity gradiometer, spacecraft, mission operations

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ARISTOTELES Mission Phases

ARISTOTELES will measure the Earth's gravity and magnetic fields in two phases:

Phase 1: First 6-8 months of the satellite mission

Altitude of about 200 km

Measures the Earth's short wavelength gravity field and crustal magnetic field at high spatial resolution

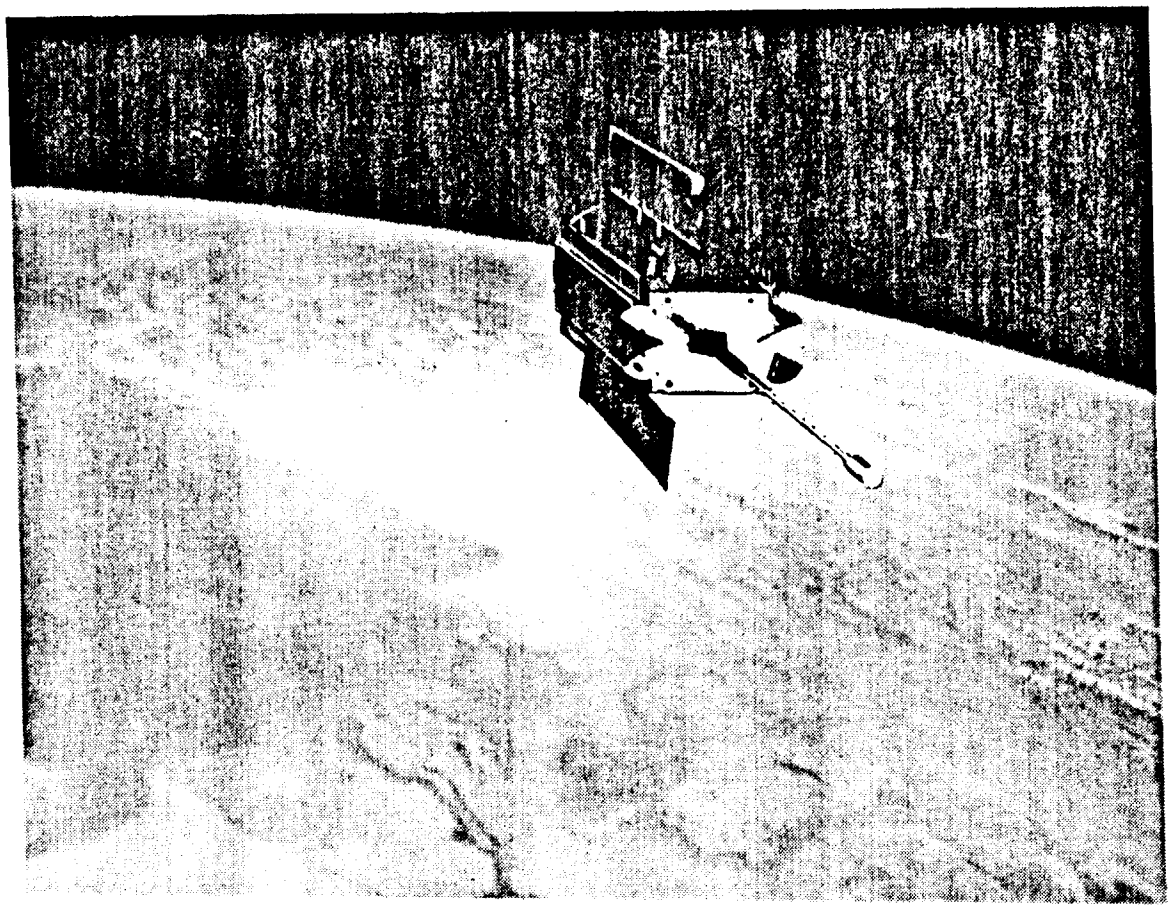
Phase 2: Remainder of the mission lifetime (about 3 years)

Altitude of about 500 km

Measures the Earth's long wavelength gravitation field and secular variation of the Earth's main magnetic field with high measurement resolution

Launch date is based on the projected solar cycle: Mid-to-late 1997 atmospheric drag will be at a minimum and conditions optimal for low altitude phase of the mission

ARISTOTELES Mission Concept



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Global Topography Mission

Designed to measure surface elevation of the continents and ice caps

Provides fundamental data for hydrology, ecology, geology, geophysics, and other disciplines

Current digital mapping in North America, Australia and Western Europe is not adequate for many global change studies

Major portions of Africa, Asia, South America, and Antarctica have poor or no topographic coverage

The Global Topographic Mission will be performed using one or both of two technological approaches:

Radar Interferometry:

High frequency (35 GHz) radar interferometer provides rapid global coverage with high spatial (30 m) and vertical (1-3 m) resolution

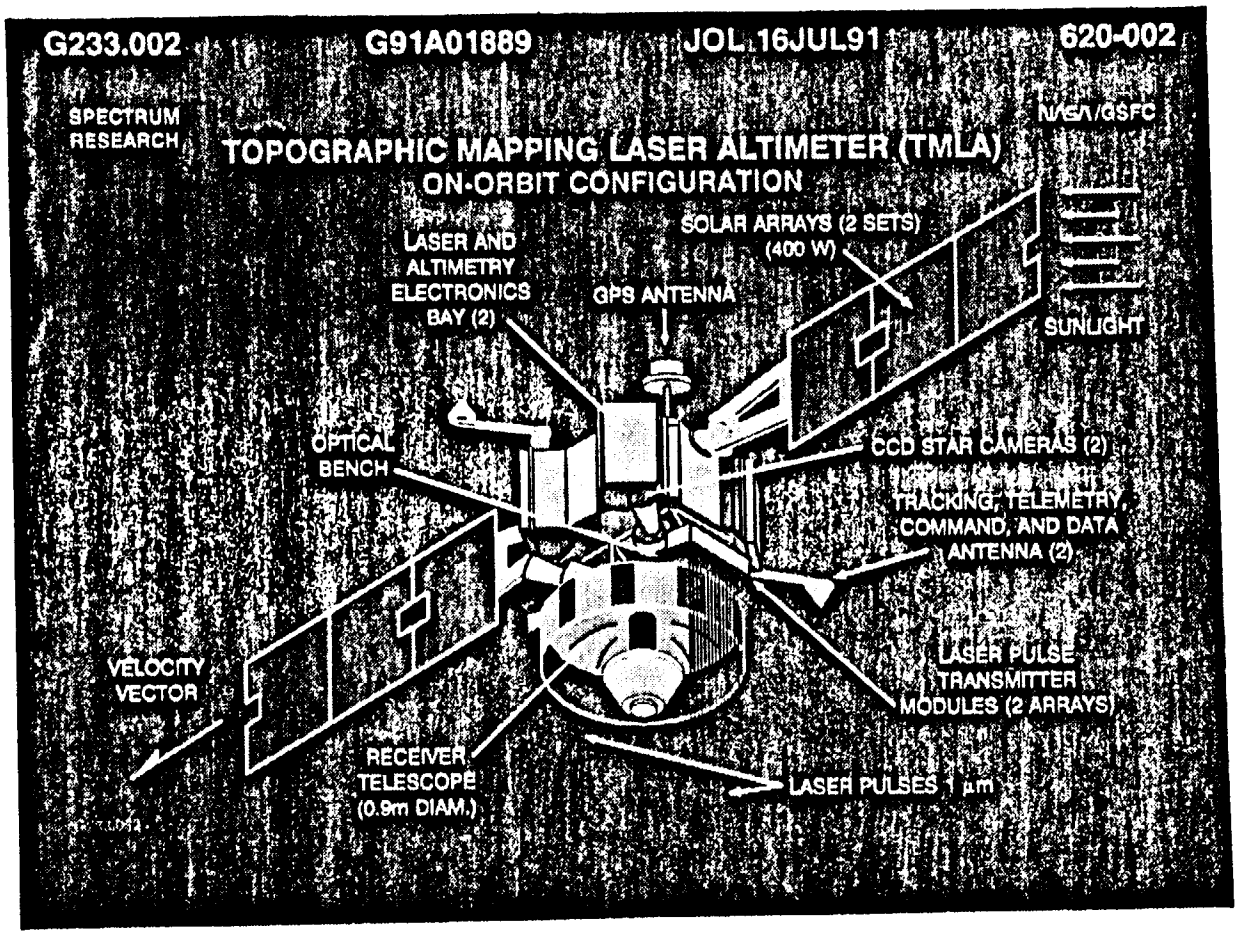
Laser Altimetry:

A multi-beam laser altimeter provides high resolution (30 m) and high vertical accuracy (about 10 cm)

Plus:

A GPS receiver provides high accuracy ephemeris (about 10 cm) to minimize systematic errors due to orbit uncertainty

GTM-Laser Altimeter Mission Concept



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GTM-Radar Interferometer Mission Concept

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EOS Synthetic Aperture Radar (EOS SAR)

EOS SAR will address a large range of scientific needs

- Sea Ice, including transport, morphology, moisture content
- Soil Moisture and Snow
- Vegetation, including canopy structure, biomass, composition
- Geological surface features, structure

Scientific needs require a multiparameter SAR

- L-band and C-band quad-polarization (US)
- X-band dual polarization (Germany/Italy)
- Multiple look angles
- Scansar, multiple resolution, and swath combinations

Further international cooperation opportunities are under discussion

- European Space Agency (ESA) and Japanese interest
- Follow-on to European Remote Sensing Satellite-1 (ERS-1) and Japanese Earth Resources Satellite-1 (JERS-1) SAR missions

EOS SAR was initially part of EOS-A

- Deferred due to mass, power, and cost implications

EOS SAR - Evolution

US Spaceborne Imaging Radar Program

SEASAT SAR	(1978)
SIR-A	(1981)
SIR-B	(1984)
SIR-C/X-SAR	(1993, 1994, 1996; partnership with Germany and Italy)

International Missions

ALMAZ-1	(1991, USSR)
ERS-1/2	(1991, 1994, ESA)
JERS-1	(1992, Japan)
RADARSAT	(1994, Canada)

Airborne Programs

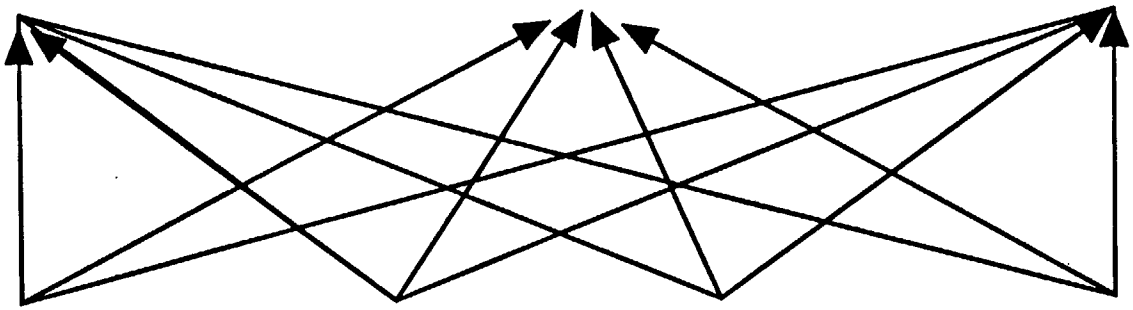
NASA/JPL AIRSAR
Navy P-3
Canada
Denmark
France
Germany

EOS SAR Mission

PHYSICAL CLIMATE SUBSYSTEM

HYDROLOGIC CYCLE

BIOGEOCHEMICAL SUBSYSTEM

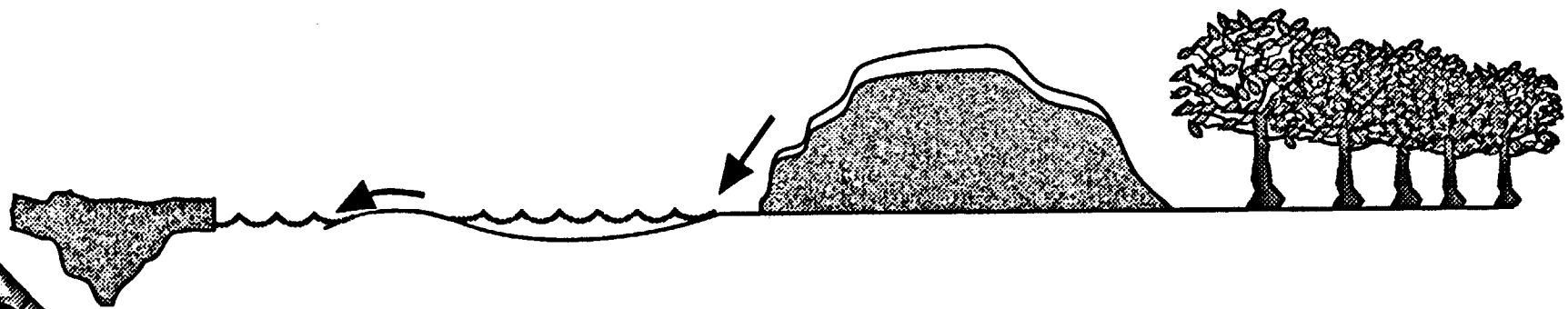


OCEAN WAVES AND MESCOSCALE FEATURES (SURFACE WAVE FIELDS AND CURRENT VELOCITY)
SEA ICE TYPE, MOTION, AND CONCENTRATION

SOIL MOISTURE
SURFACE WATER DISTRIBUTION
SNOW MOISTURE WATER EQUIVALENT, AND EXTENT
GLACIER AND ICE SHEET EXTENT AND VELOCITY

TOPOGRAPHY
EROSION
SURFACE ROUGHNESS
LANDFORMS
SAND DEPTH

VEGETATION TYPE AND EXTENT (INCLUDING DEFORESTATION)
BIOMASS (WOODY AND GREEN)
PHENOLOGIC AND ENVIRONMENTAL STATE
WETLAND EXTENT AND FREQUENCY
LANDSCAPE PATTERN



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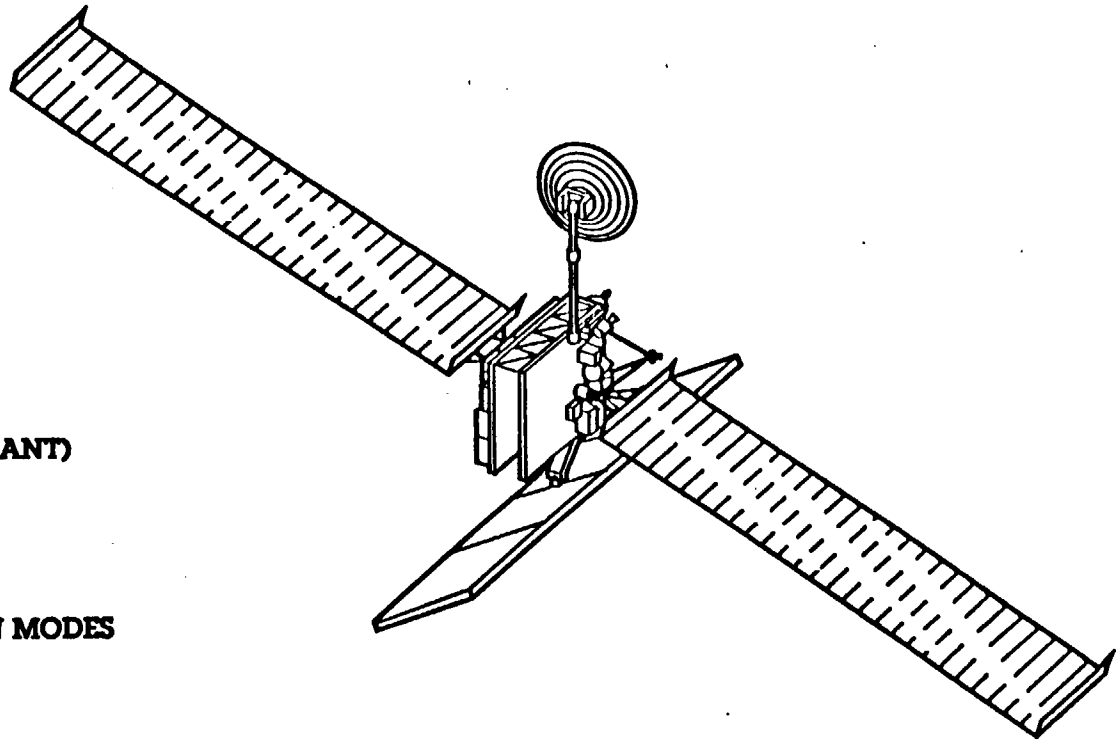
EOS SAR Mission Spacecraft Summary

- DRY MASS - 2963 KG
- LAUNCHED MASS - 3306 KG
- AVE POWER - 2498 W
- PEAK POWER - 7332 WS
- 3-AXIS STABILIZED
- 300 MBPS DOWNLINK MAX
- 15 MBPS AVE
- 100 KBPS UPLINK
- 5-YEAR DESIGN LIFETIME
- MONO PROPELLANT HYDRAZINE
  DRAG MAKE UP (143 KG PROPELLANT)
- PASSIVE THERMAL CONTROL
- 1078 KG SAR
- QUAD POLARIZATION L-BAND
- DUAL POLARIZATION X, C-BAND
- EOS MAPPING/HIGH RESOLUTION MODES



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Geostationary Earth Observatory (GEO)

Several spacecraft oriented over fixed equatorial locations positioned around the world

- Observations of vital Earth system processes that cannot be made from polar or low-inclination orbit
- Rapidly developing phenomena and diurnal processes viewed at any time and on a continuous basis

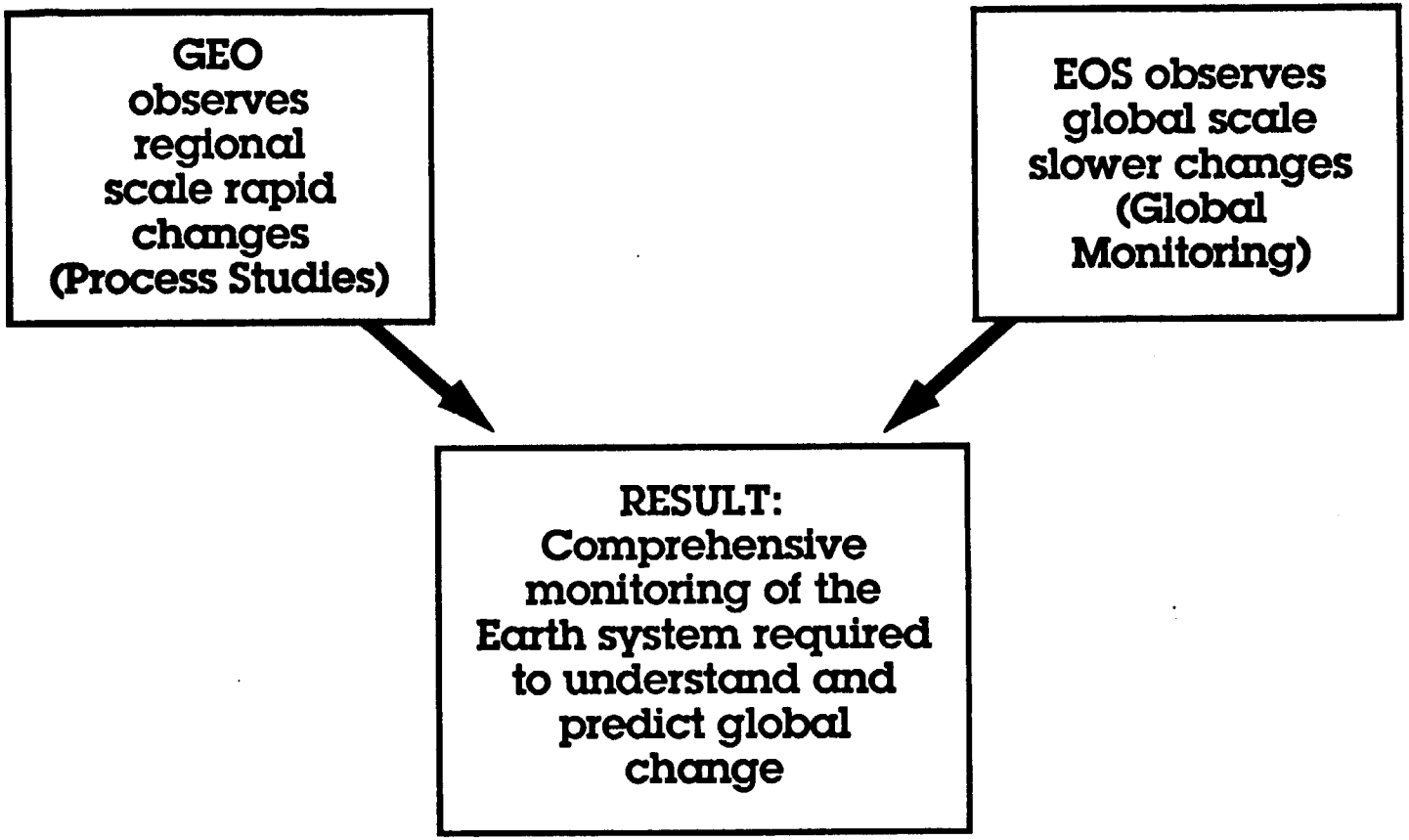
Instruments complementary to EOS

- Direct intercomparison of EOS/GEO observations
- Data integrated in the EOS Data and Information System

Science measurements

- Crucial to understanding short-term processes essential for the development of predictive Earth system models

Why GEO?



With GEO, the impact of large daily fluctuations on long-term global change will be understood.

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Key GEO Mission Characteristics

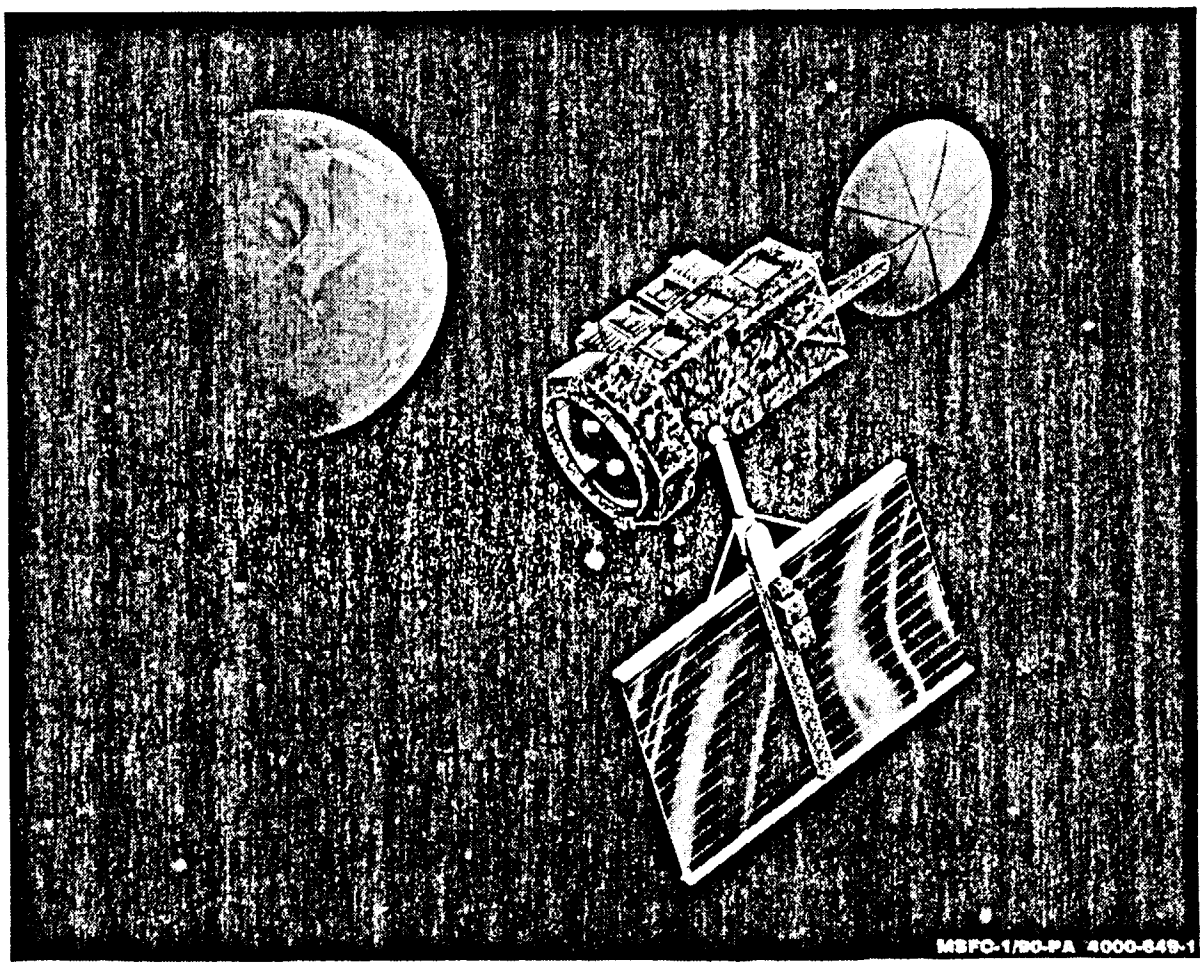
GEO permits time-continuous observations necessary for comprehensive physical and dynamical modeling of the global Earth System

Diurnal observations
Multiple image compositing
Timely observation of transient events
Long-duration sensor staring
Hemispheric coverage
Fast sequential imaging
Constant viewing angle
Varying sun angle
Continuous solar observations

Potential GEO facility instruments include:

Microwave Imager/Sounder
IR Atmospheric Profiler
Visible/IR Spectrometer (moderate resolution)
Visible/IR High-Resolution Imager
Lightning Sensor

Geostationary Earth Observatory (GEO) Mission Concept



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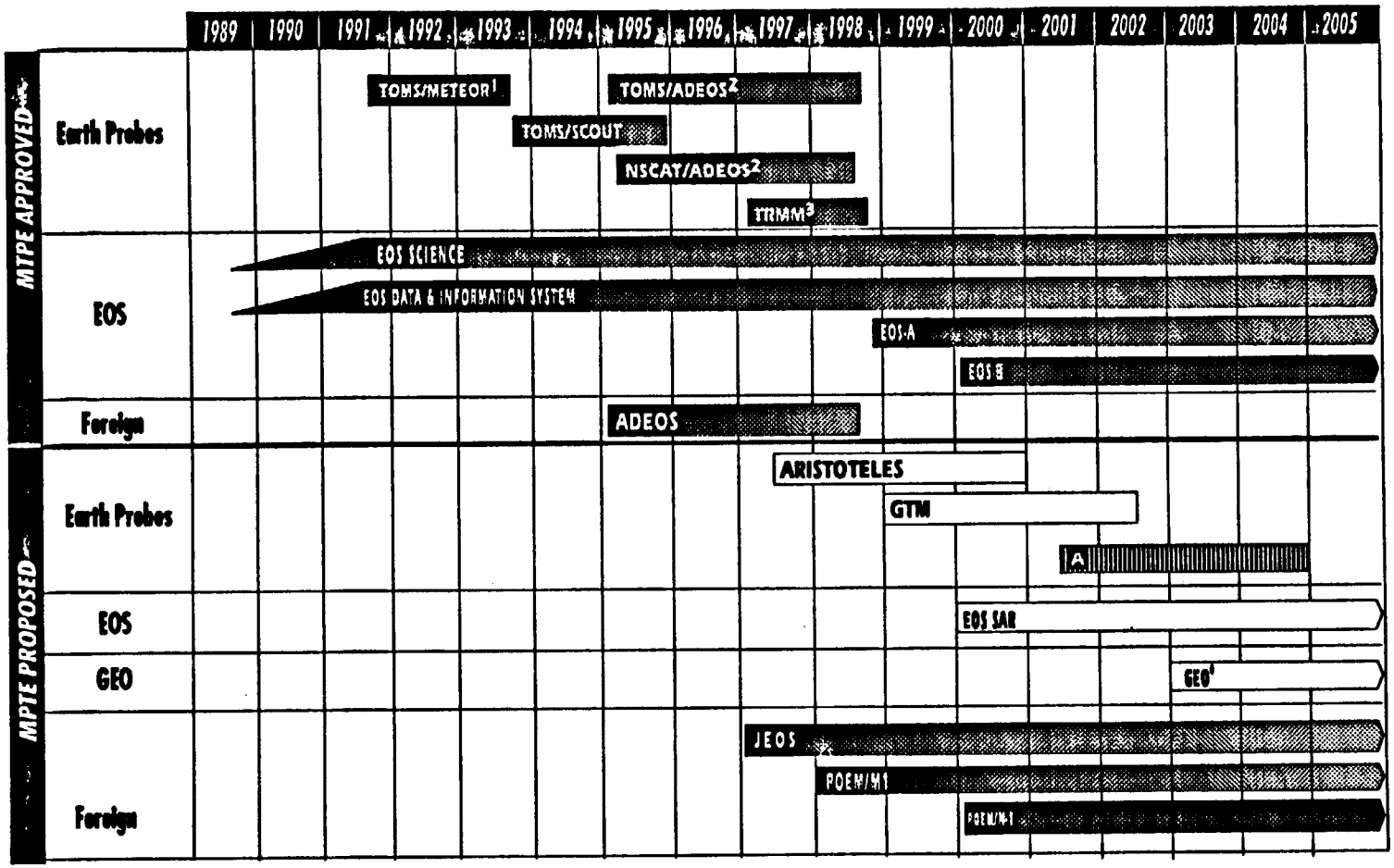
MTPE Space Assets for Global Change Studies



Future Earth Probe Candidate

Proposed Mission

Approved, Under Development, or Operating Mission

[1] USSR Satellite
[2] Japanese Satellite
[3] Joint with Japan
[4] Proposed International Cooperation

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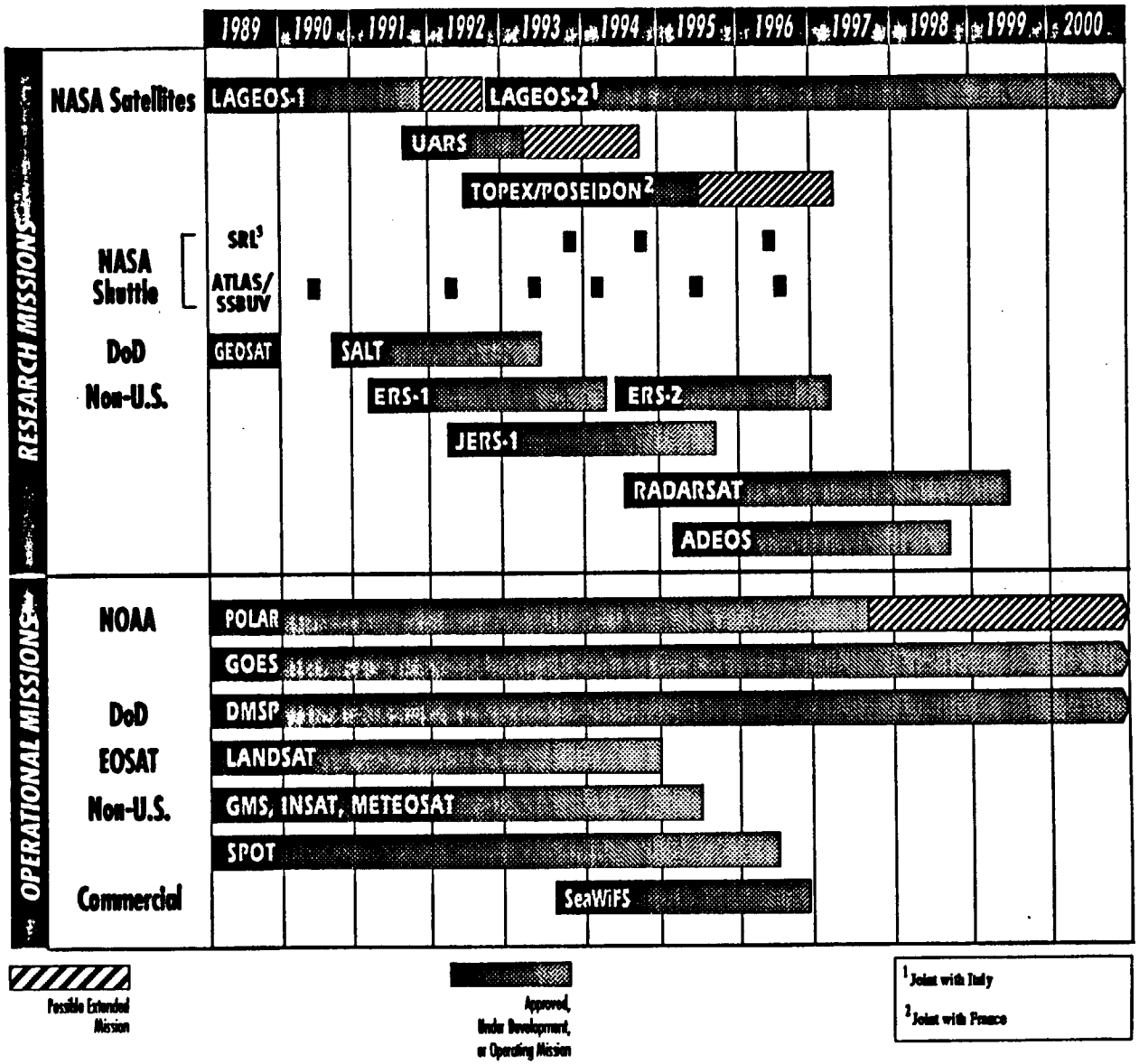
Base Program Space Assets for Global Change Studies



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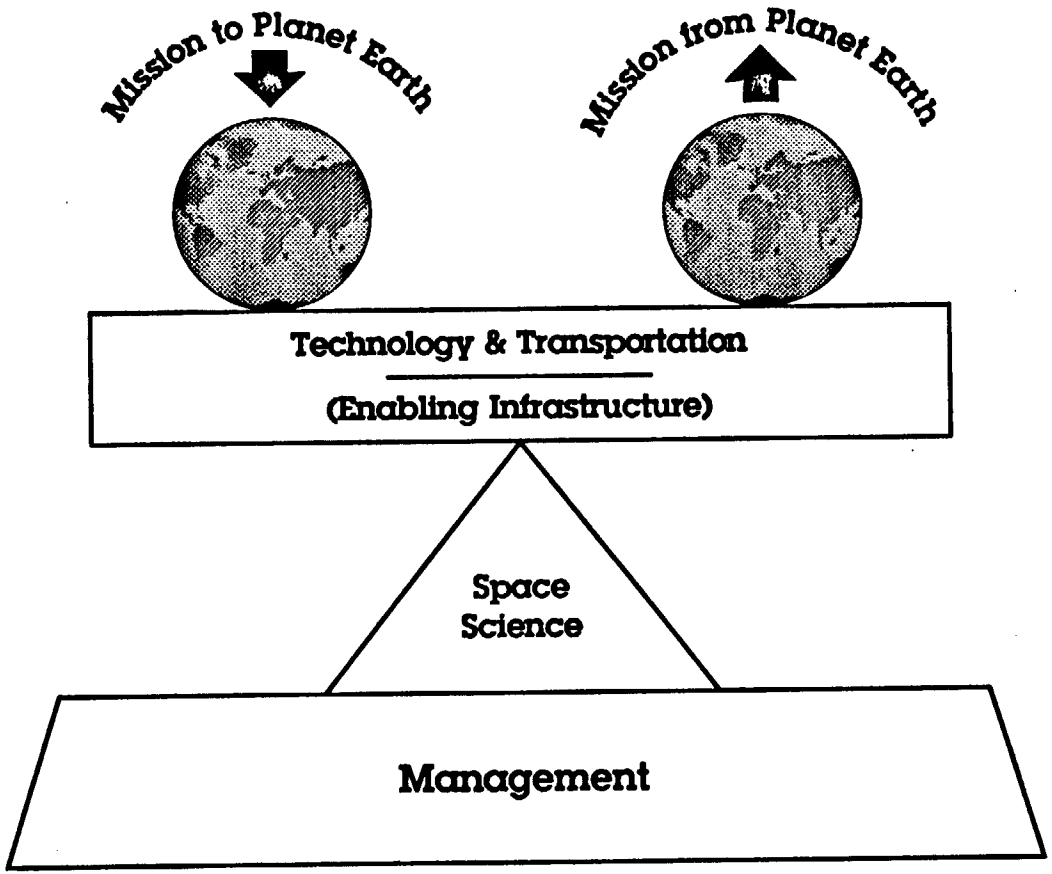

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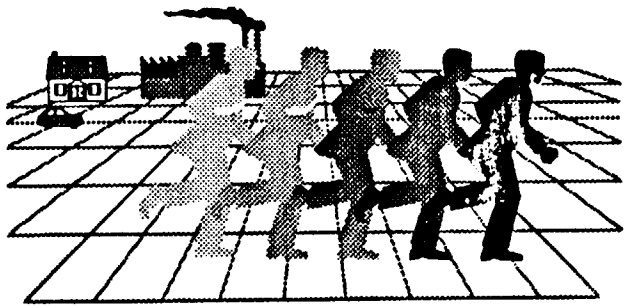

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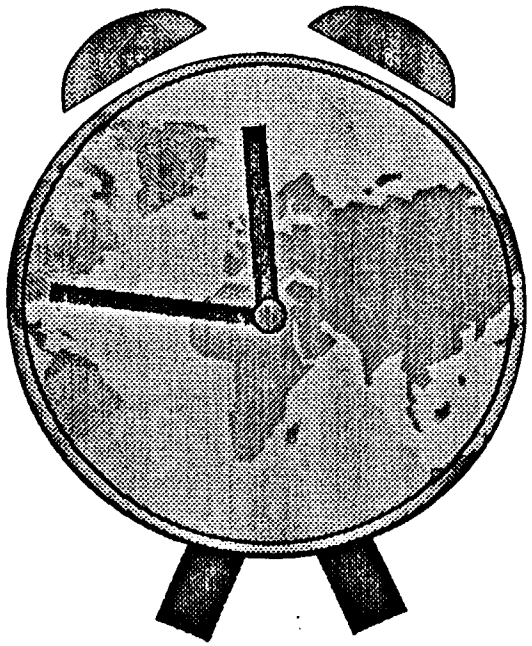

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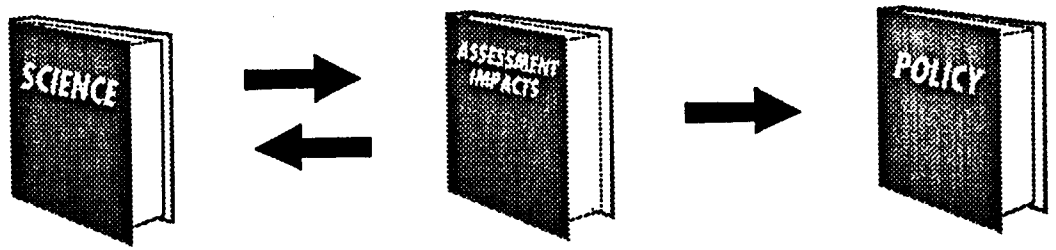

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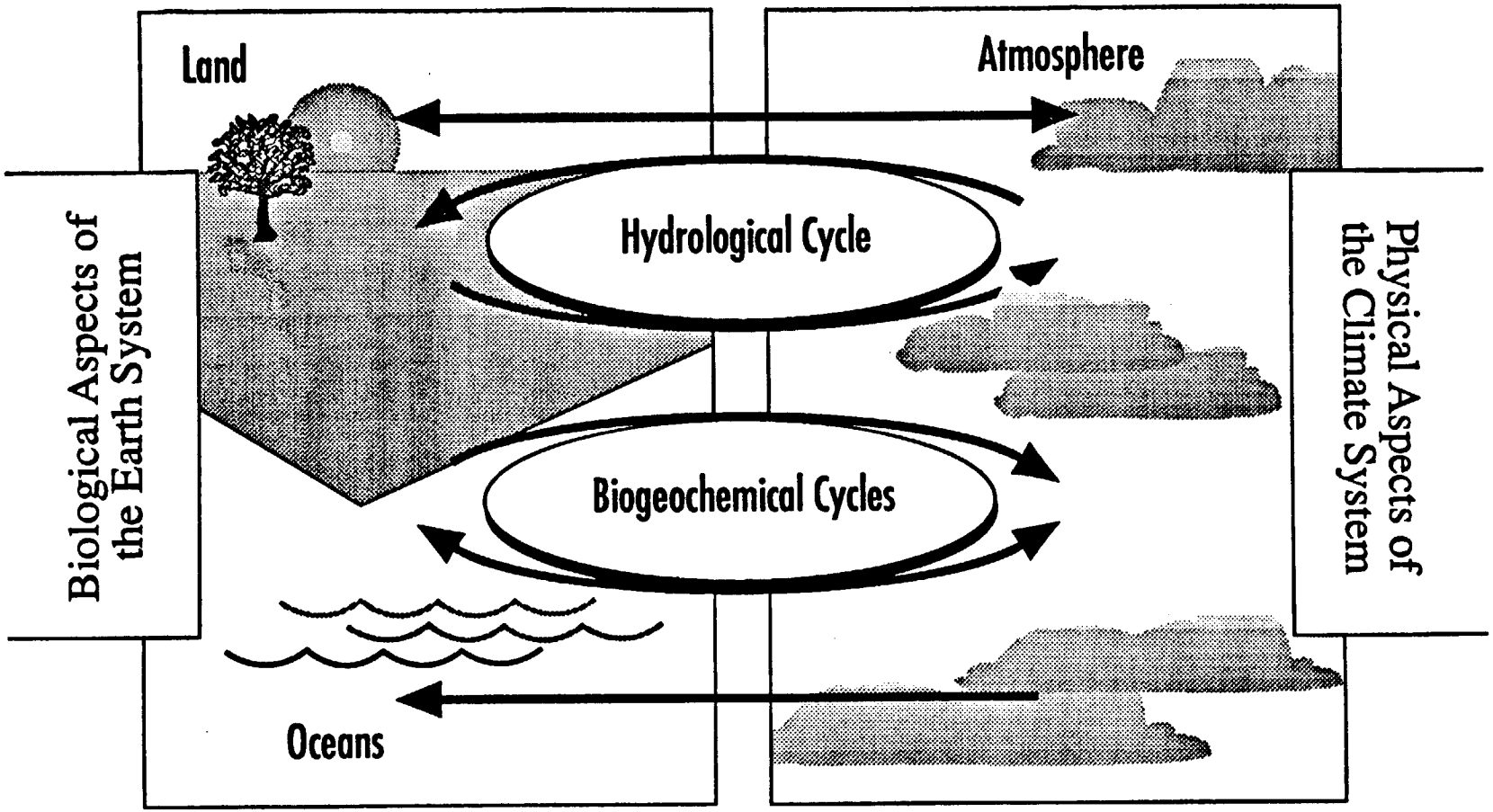

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Role of clouds

Role of oceans

Role of polar ice sheets

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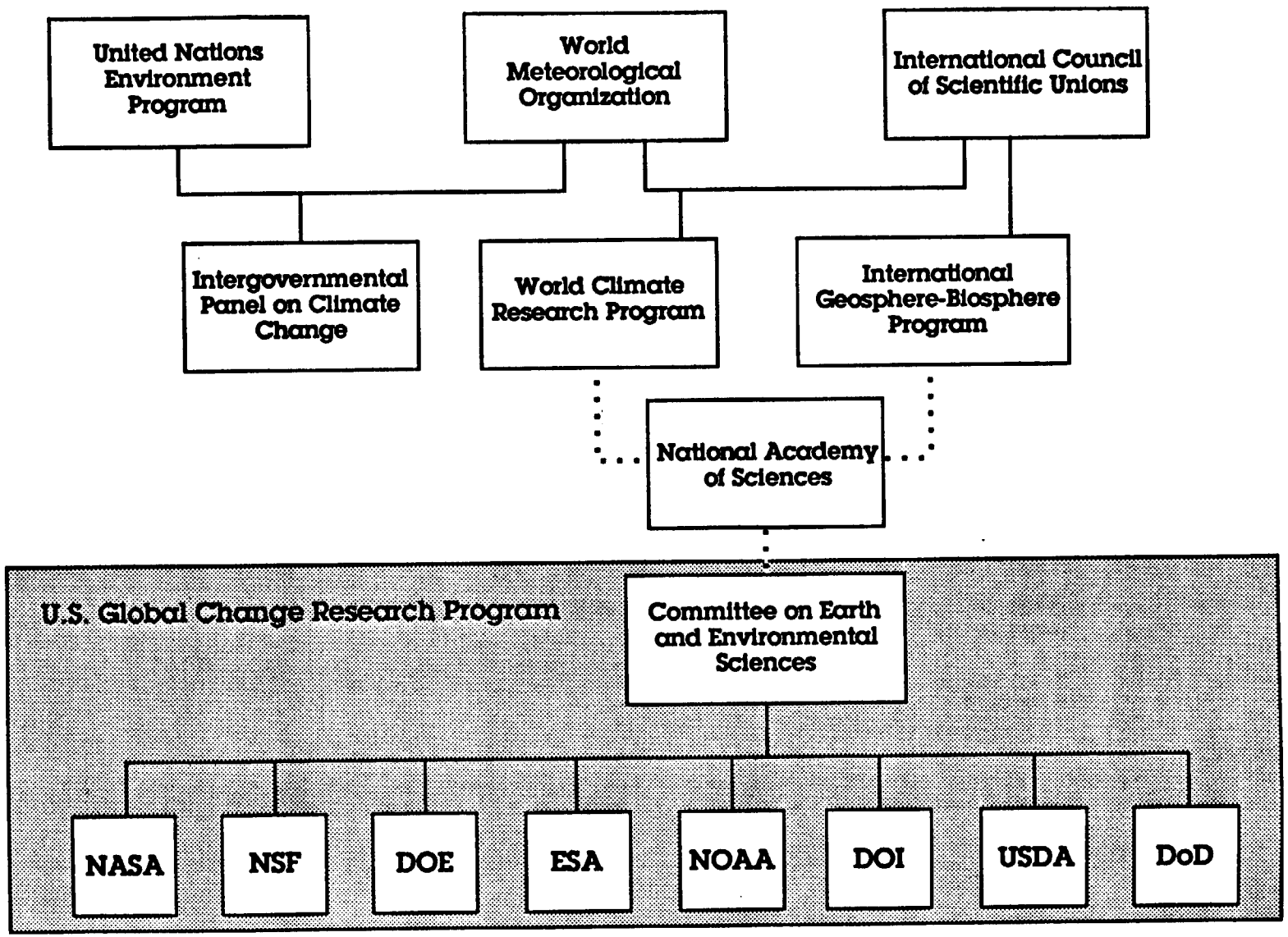

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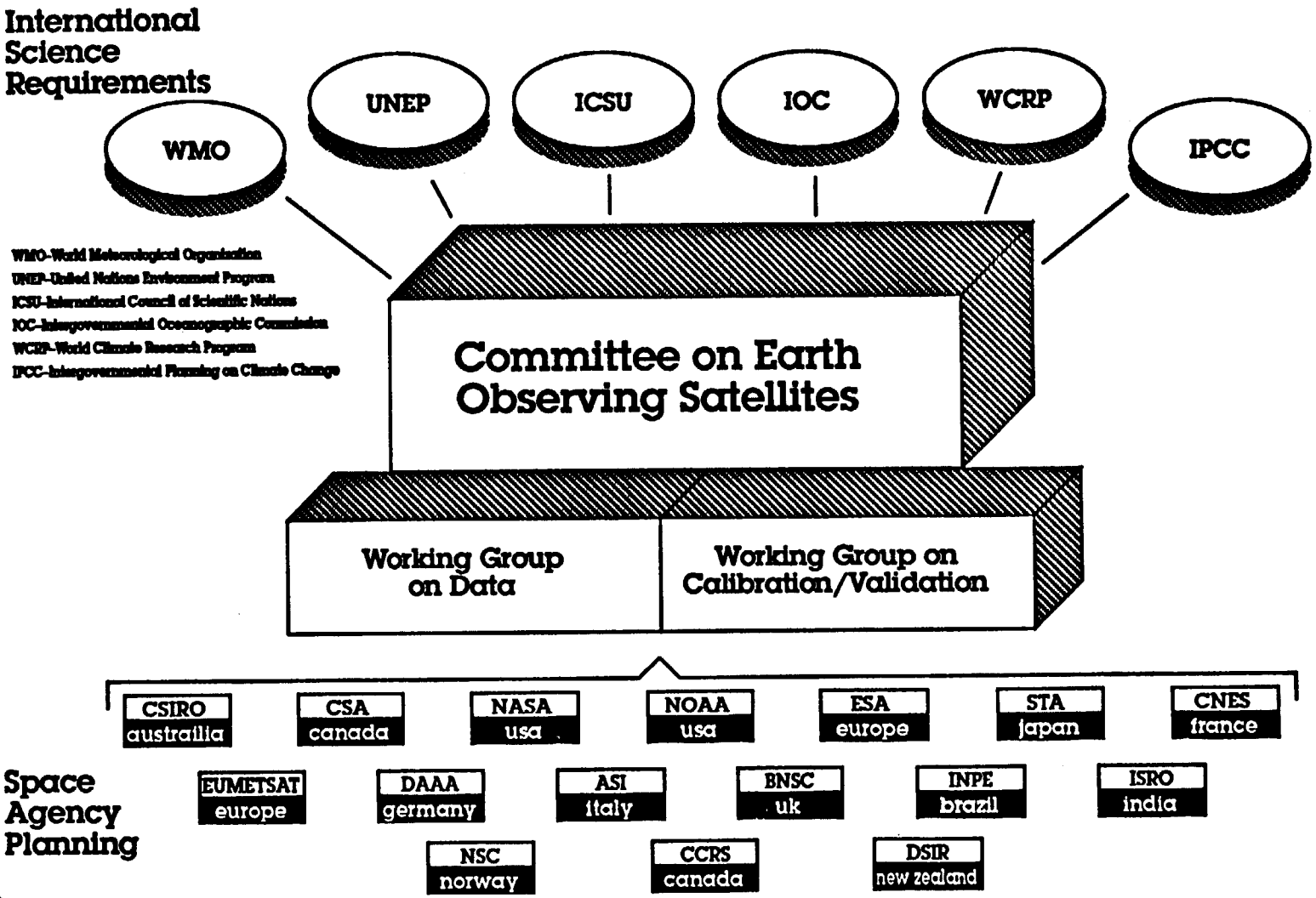

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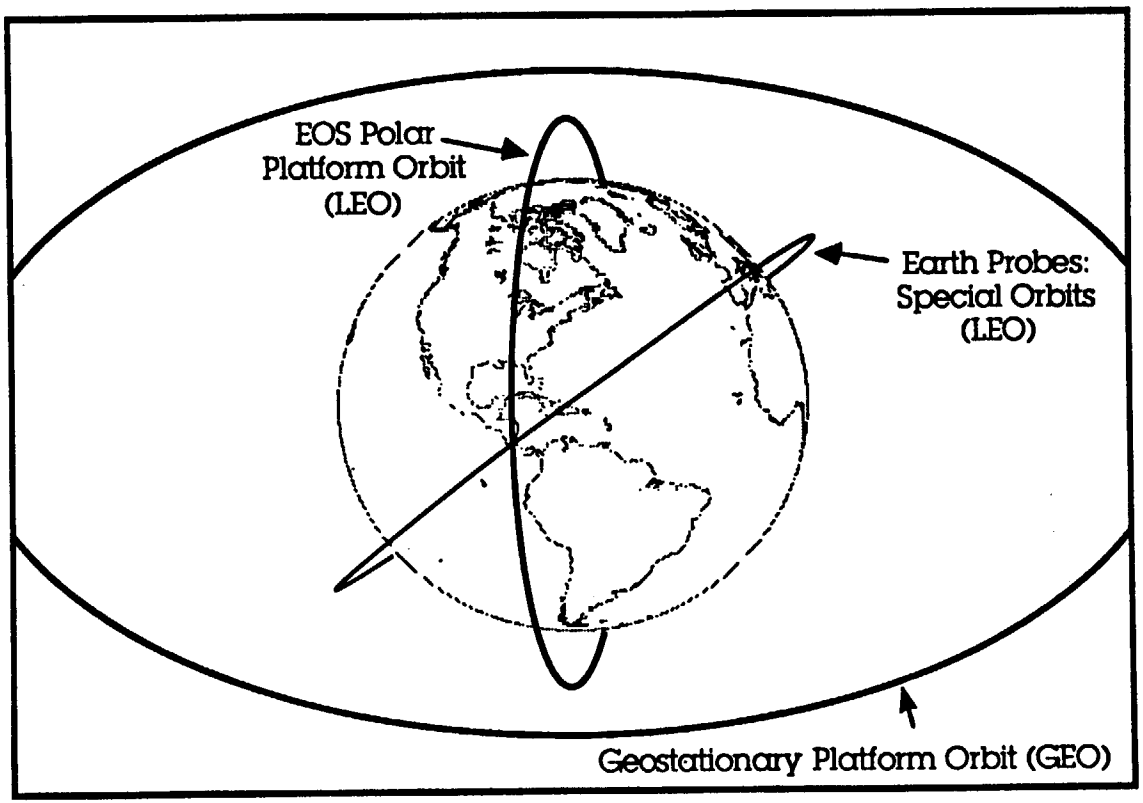
Comprehensive Understanding Requires Comprehensive Space Observations



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Mission To Planet Earth
Complementary Space Observations

Sun-synchronous polar orbits

- Global coverage: Fixed crossing times
- Repeat sampling at intervals of hours to weeks
- Laser, radar, and passive remote sensing

Low-inclination, low-altitude orbits

- Tropical coverage: All local times
- Repeat sampling at intervals of hours to weeks
- Laser, radar, and passive remote sensing

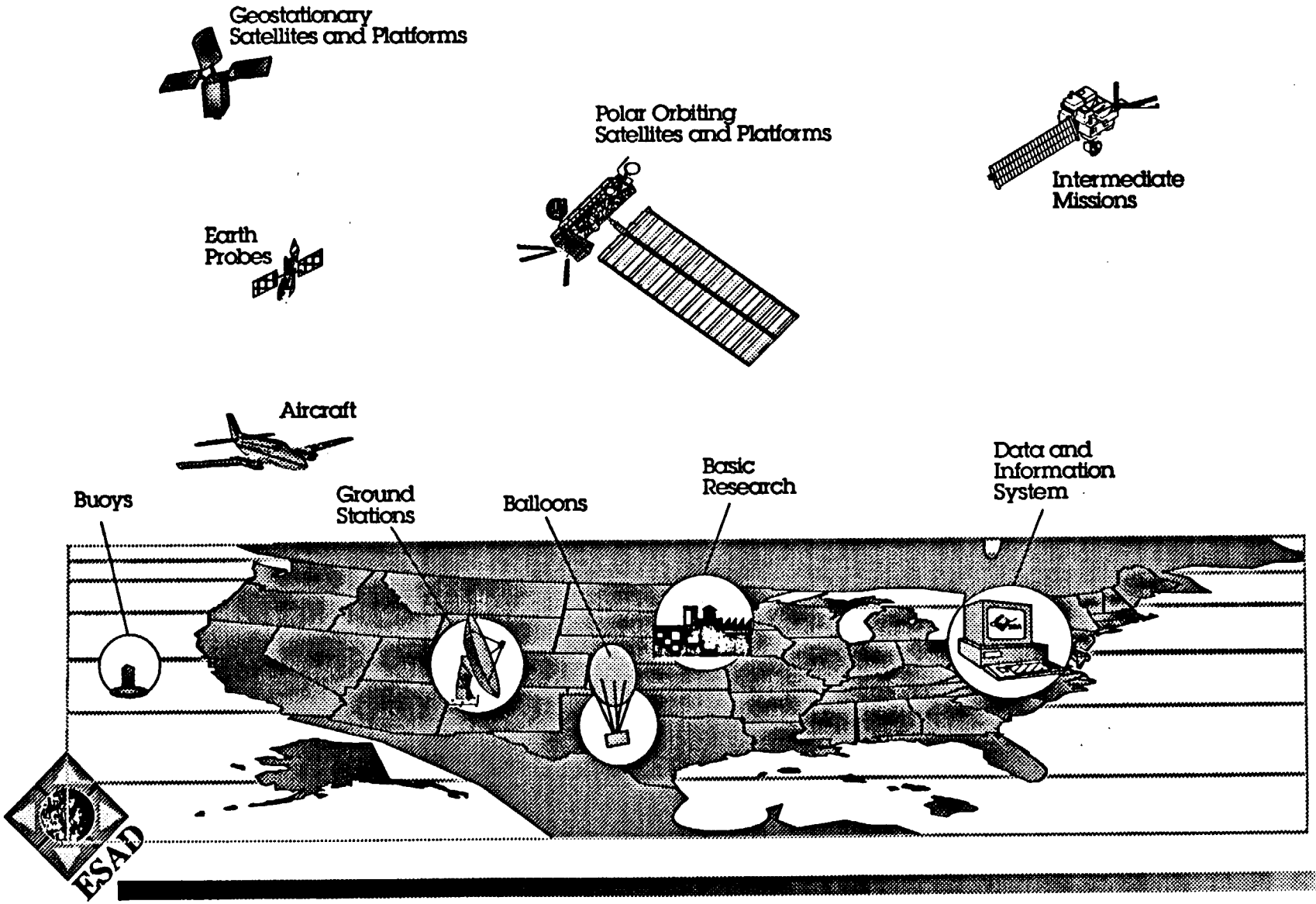
Geostationary orbits

- Regional views or full Earth disk
- Continuous coverage of selected areas
- Passive remote sensing

Ground Measurements

- Calibration and validation of satellite observations
- Local and regional process studies

Mission to Planet Earth



Approved Missions in ESAD's Base and MTPE Programs

	Base Missions	Launch Date
ATLAS	Atmospheric Laboratory for Applications and Science-1	April 1992
	Atmospheric Laboratory for Applications and Science-2	April 199
	Atmospheric Laboratory for Applications and Science-3	January 1994
	Atmospheric Laboratory for Applications and Science-4	January 1995
	Atmospheric Laboratory for Applications and Science-5	January 1996
	Atmospheric Laboratory for Applications and Science-6	January 1997
LAGEOS-II	Laser Geodynamics Satellite-II	September 1992
SRL	Shuttle Research Laboratory-1 (with SIR-C and X-SAR) (Germany)	September 1993
	Shuttle Research Laboratory-2 (with SIR-C and X-SAR) (Germany)	September 1994
	Shuttle Research Laboratory-3 (with SIR-C and X-SAR) (Germany)	January 1996
SBUV	Solar Backscatter Ultraviolet/Version-2 (on NOAA-I)	December 1991
	Solar Backscatter Ultraviolet/Version-2 (on NOAA-K)	July 1994
	Solar Backscatter Ultravioltet/Version-2 (on NOAA-M)	February 1997
SeaWIFS	Sea Wild Field Sensor (data purchase only)	August 1993
UARS	Upper Atmosphere Research Satellite	September 1991
TOPEX/Poseidon	Ocean Topography Experiment/Poseidon (France)	July 1992
	MTPE approved	
Earth Probes		
TOMS	Total Ozone Mapping Spectrometer/Meteor-3 (USSR)	August 1991
	Total Ozone Mapping Spectrometer/Scout	September 1993
	Total Ozone Mapping Spectrometer/ADEOS (Japan)	February 1995
NSCAT	NASA Scatterometer/ADEOS (Japan)	February 1995
TRMM	Tropical Rainfall Monitoring Mission (Japan)	February 1997
EOS-A Series	Earth Observing System-A1/A2/A3	December 1998 (A1)
EOS-B Series	Earth Observing System-A1/A2/A3	2001 (B1)

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Proposed Missions in ESAD's MTPE Program

	Earth Probes (level-of-effort)	Launch Date
AMAG	ARISTOTELES Magnetic Field Experiment	1997
GTM	Global Topography Mission	1999
	Others TBD	
	Intermediate Missions	
EOS SAR	EOS Synthetic Aperture Radar	2000
	Major Missions	
GEO	Geostationary Earth Observatory	2003

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Airborne Science and Applications Program

Present Program includes operation of a single DC-8 aircraft. This aircraft supports major segments of the Space Science and Applications program dealing with the Earth, the oceans, and the atmosphere. Recently completed or planned program support missions:

Solid Earth Science, Biogeochemistry & Geophysics, Ecosystem Dynamics & Biogeochemical Cycles Programs - Observational campaigns utilizing the Airborne Synthetic Aperture Radar (SAR); Multiple Airborne Campaign - Europe

Atmospheric Chemistry Program - Studies of Polar Stratospheric Chemistry and Ozone Depletion through intensive Airborne observation campaigns

Radiation, Dynamics & Hydrology Program - Global Aerosol Backscatter Experiment (GLOBE)

Mission To Planet Earth Support - Ground Truth Observations for EOS Precursor and Earth Probe Missions

Because of its long range and high altitude capabilities and the need for these characteristics by the Earth sciences research community, the NASA DC-8 is over subscribed

Typically, demand exceeds availability. Downtime due to integration and deintegration of the AIRSAR instrument results in loss of available flying time

Demand and criticality of this resource to the NASA and US Global Change Research Programs justify the acquisition of a second DC-8 to dedicate to the AIRSAR instrument

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The Earth Probes Program—Mission Definition

Definition of all missions based on science measurement requirements identified by the National Academy of Sciences (NAS)

A Strategy for Earth Science from Space in the 1980's and 1990's, part 1: Solid Earth and Oceans, National Academy Press, 1982.

A Strategy for Earth Science from Space in the 1980's and 1990's, part 2: Atmosphere and Interactions with the Solid Earth and Oceans, National Academy Press, 1985.

Strategy for Earth Explorers in Global Earth Sciences, National Academy Press, 1988.

Space Science in the Twenty-First Century, Imperatives for the Decades 1995 to 2015, National Academy Press, 1988.

The U.S. Global Change Research Program, An Assessment of the FY 1991 Plans, National Academy Press, 1990.

Research Strategies for the U.S. Global Change Research Program, National Academy Press, 1990.

Assessment of Satellite Earth Observation Programs 1991, Committee on Earth Studies, National Academy Press, 1991.

The Earth Probes Program

Approved

- Total Ozone Mapping Spectrometer (TOMS)/Meteor—1991
- TOMS/Free Flyer—1993
- TOMS/ADEOS—1995
- NASA Scatterometer (NSCAT)/ADEOS—1995
- Tropical Rainfall Measuring Mission (TRMM)—1997

Proposed

- Applications and Research Involving Space Technologies Observing the Earth's Field from Low Orbiting Satellite (ARISTOTELES)
- Global Topography Mission (GTM)

Future (Not in Order of Priority)

- Geopotential Research Mission
- Measurement of Air Pollution from Satellites
- Mesoscale Research Explorer
- Magnetic Field Experiment
- Rain Mapping Mission
- Earth Radiation Budget Mission
- Solar Input Mission
- Volcano Mapping Mission
- Other complementary missions

ARISTOTELES Mission

ARISTOTELES = Applications and Research Involving Space Technologies Observing The Earth's field from Low Earth orbiting Satellite

Scientific objectives contribute to the understanding of:

- The dynamics of the Earth's core and origin of the magnetic field
- The composition and dynamics of the mantle
- The structure and dynamics of the continental crust
- Improved ocean circulation models through high resolution ocean geoid

ARISTOTELES is a joint NASA/ESA mission

- NASA provides: scalar and vector magnetometers, onboard Global Positioning Satellite (GPS) receiver, and tracking
- ESA provides: gravity gradiometer, spacecraft, mission operations

ARISTOTELES Mission Phases

ARISTOTELES will measure the Earth's gravity and magnetic fields in two phases:

Phase 1: First 6-8 months of the satellite mission

Altitude of about 200 km

Measures the Earth's short wavelength gravity field and crustal magnetic field at high spatial resolution

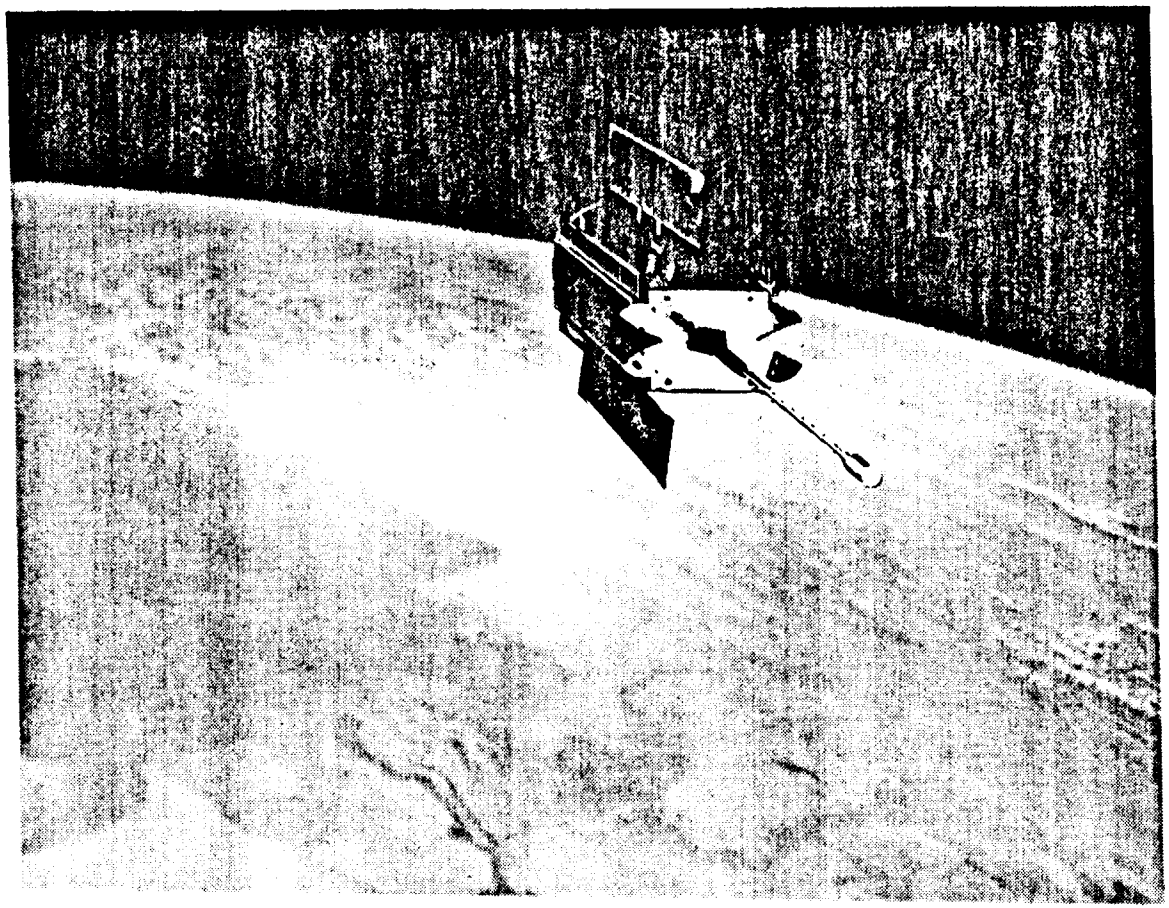
Phase 2: Remainder of the mission lifetime (about 3 years)

Altitude of about 500 km

Measures the Earth's long wavelength gravitation field and secular variation of the Earth's main magnetic field with high measurement resolution

Launch date is based on the projected solar cycle: Mid-to-late 1997 atmospheric drag will be at a minimum and conditions optimal for low altitude phase of the mission

ARISTOTELES Mission Concept



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Global Topography Mission

Designed to measure surface elevation of the continents and ice caps

Provides fundamental data for hydrology, ecology, geology, geophysics, and other disciplines

Current digital mapping in North America, Australia and Western Europe is not adequate for many global change studies

Major portions of Africa, Asia, South America, and Antarctica have poor or no topographic coverage

The Global Topographic Mission will be performed using one or both of two technological approaches:

Radar Interferometry:

High frequency (35 GHz) radar interferometer provides rapid global coverage with high spatial (30 m) and vertical (1-3 m) resolution

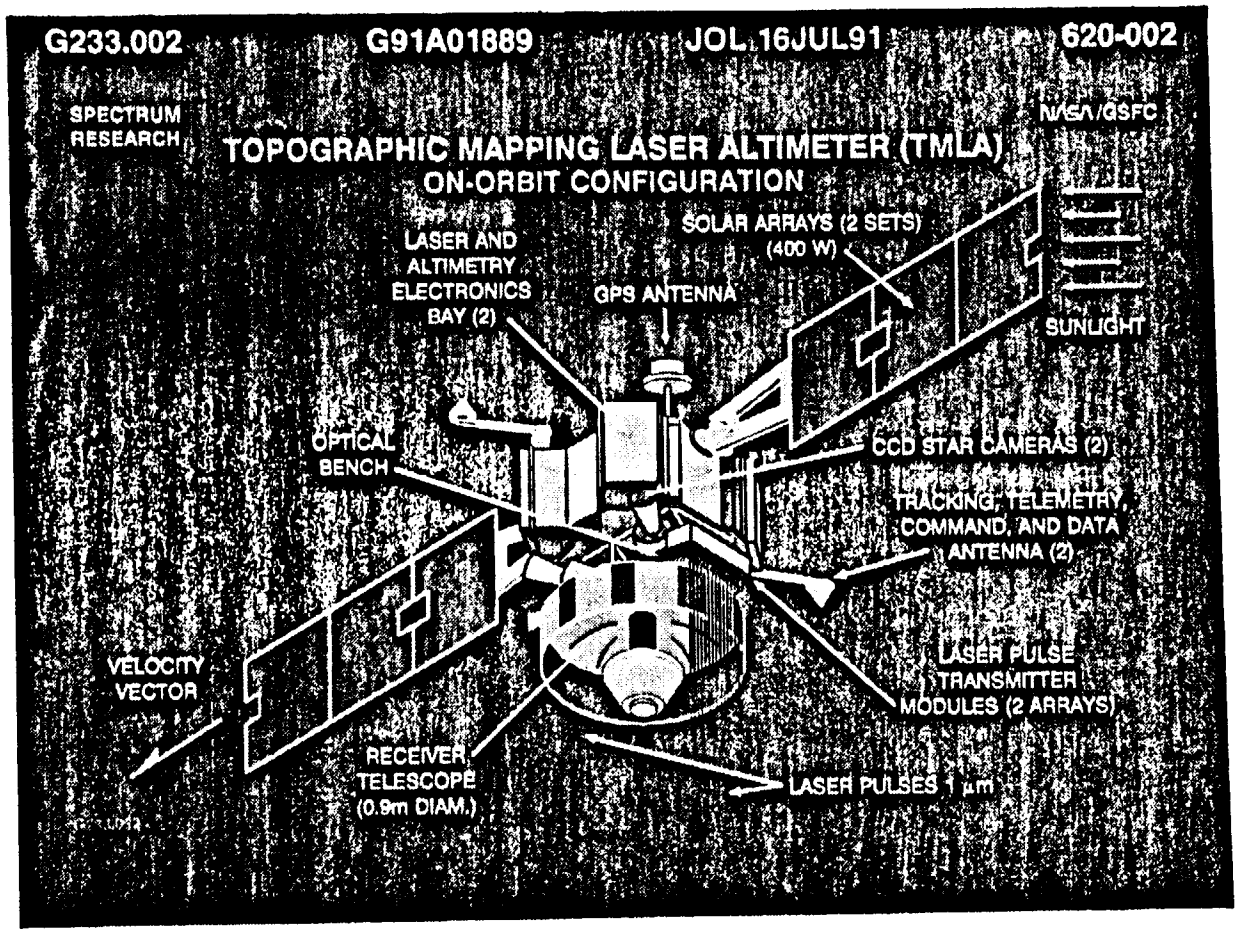
Laser Altimetry:

A multi-beam laser altimeter provides high resolution (30 m) and high vertical accuracy (about 10 cm)

Plus:

A GPS receiver provides high accuracy ephemeris (about 10 cm) to minimize systematic errors due to orbit uncertainty

GTM-Laser Altimeter Mission Concept



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GTM-Radar Interferometer Mission Concept

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EOS Synthetic Aperture Radar (EOS SAR)

EOS SAR will address a large range of scientific needs

- Sea Ice, including transport, morphology, moisture content
- Soil Moisture and Snow
- Vegetation, including canopy structure, biomass, composition
- Geological surface features, structure

Scientific needs require a multiparameter SAR

- L-band and C-band quad-polarization (US)
- X-band dual polarization (Germany/Italy)
- Multiple look angles
- Scansar, multiple resolution, and swath combinations

Further international cooperation opportunities are under discussion

- European Space Agency (ESA) and Japanese interest
- Follow-on to European Remote Sensing Satellite-1 (ERS-1) and Japanese Earth Resources Satellite-1 (JERS-1) SAR missions

EOS SAR was initially part of EOS-A

- Deferred due to mass, power, and cost implications

EOS SAR - Evolution

US Spaceborne Imaging Radar Program

SEASAT SAR	(1978)
SIR-A	(1981)
SIR-B	(1984)
SIR-C/X-SAR	(1993, 1994, 1996; partnership with Germany and Italy)

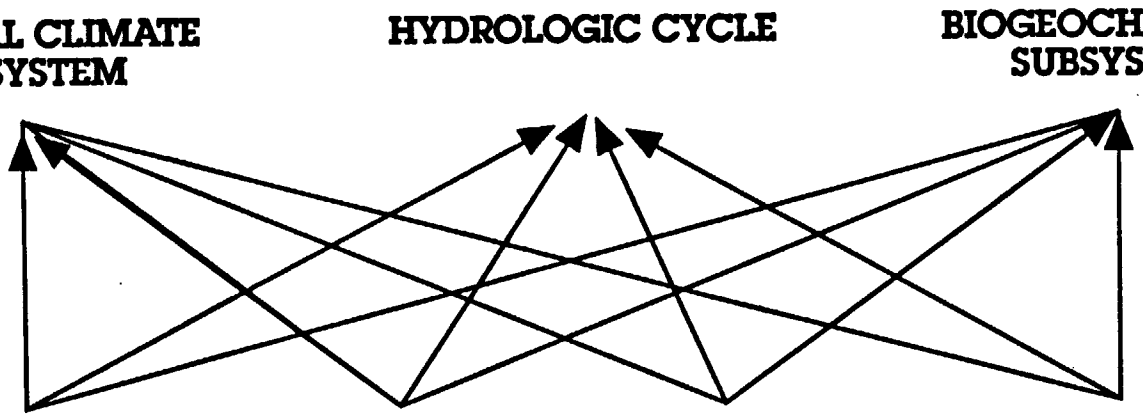
International Missions

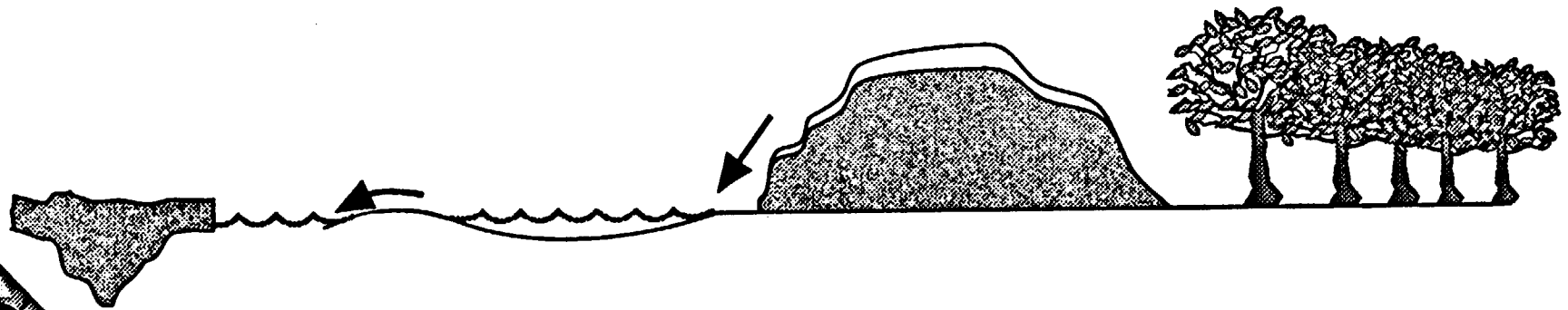
ALMAZ-1	(1991, USSR)
ERS-1/2	(1991, 1994, ESA)
JERS-1	(1992, Japan)
RADARSAT	(1994, Canada)

Airborne Programs

NASA/JPL AIRSAR
Navy P-3
Canada
Denmark
France
Germany

EOS SAR Mission





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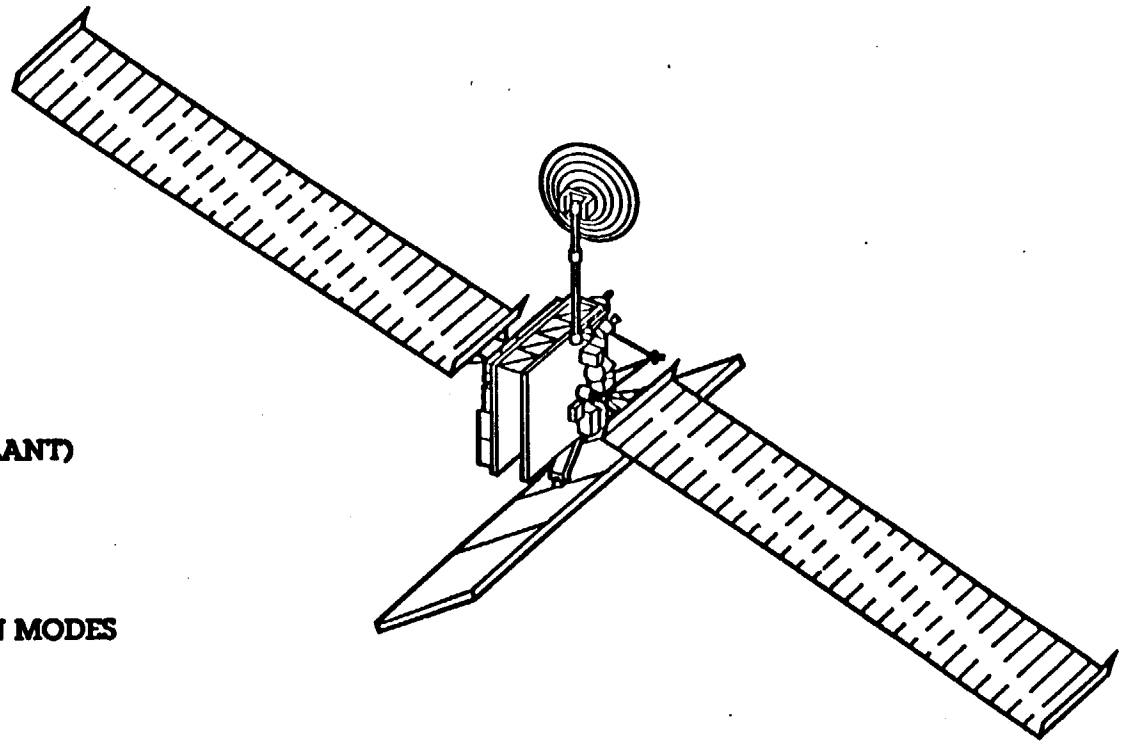
EOS SAR Mission Spacecraft Summary

- DRY MASS - 2963 KG
- LAUNCHED MASS - 3306 KG
- AVE POWER - 2498 W
- PEAK POWER - 7332 WS
- 3-AXIS STABILIZED
- 300 MBPS DOWNLINK MAX
- 15 MBPS AVE
- 100 KBPS UPLINK
- 5-YEAR DESIGN LIFETIME
- MONO PROPELLANT HYDRAZINE
  DRAG MAKE UP (143 KG PROPELLANT)
- PASSIVE THERMAL CONTROL
- 1078 KG SAR
- QUAD POLARIZATION L-BAND
- DUAL POLARIZATION X, C-BAND
- EOS MAPPING/HIGH RESOLUTION MODES



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Geostationary Earth Observatory (GEO)

Several spacecraft oriented over fixed equatorial locations positioned around the world

- Observations of vital Earth system processes that cannot be made from polar or low-inclination orbit
- Rapidly developing phenomena and diurnal processes viewed at any time and on a continuous basis

Instruments complementary to EOS

- Direct intercomparison of EOS/GEO observations
- Data integrated in the EOS Data and Information System

Science measurements

- Crucial to understanding short-term processes essential for the development of predictive Earth system models

Why GEO?

GEO observes regional scale rapid changes (Process Studies)

EOS observes global scale slower changes (Global Monitoring)

RESULT: Comprehensive monitoring of the Earth system required to understand and predict global change

With GEO, the impact of large daily fluctuations on long-term global change will be understood.

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Key GEO Mission Characteristics

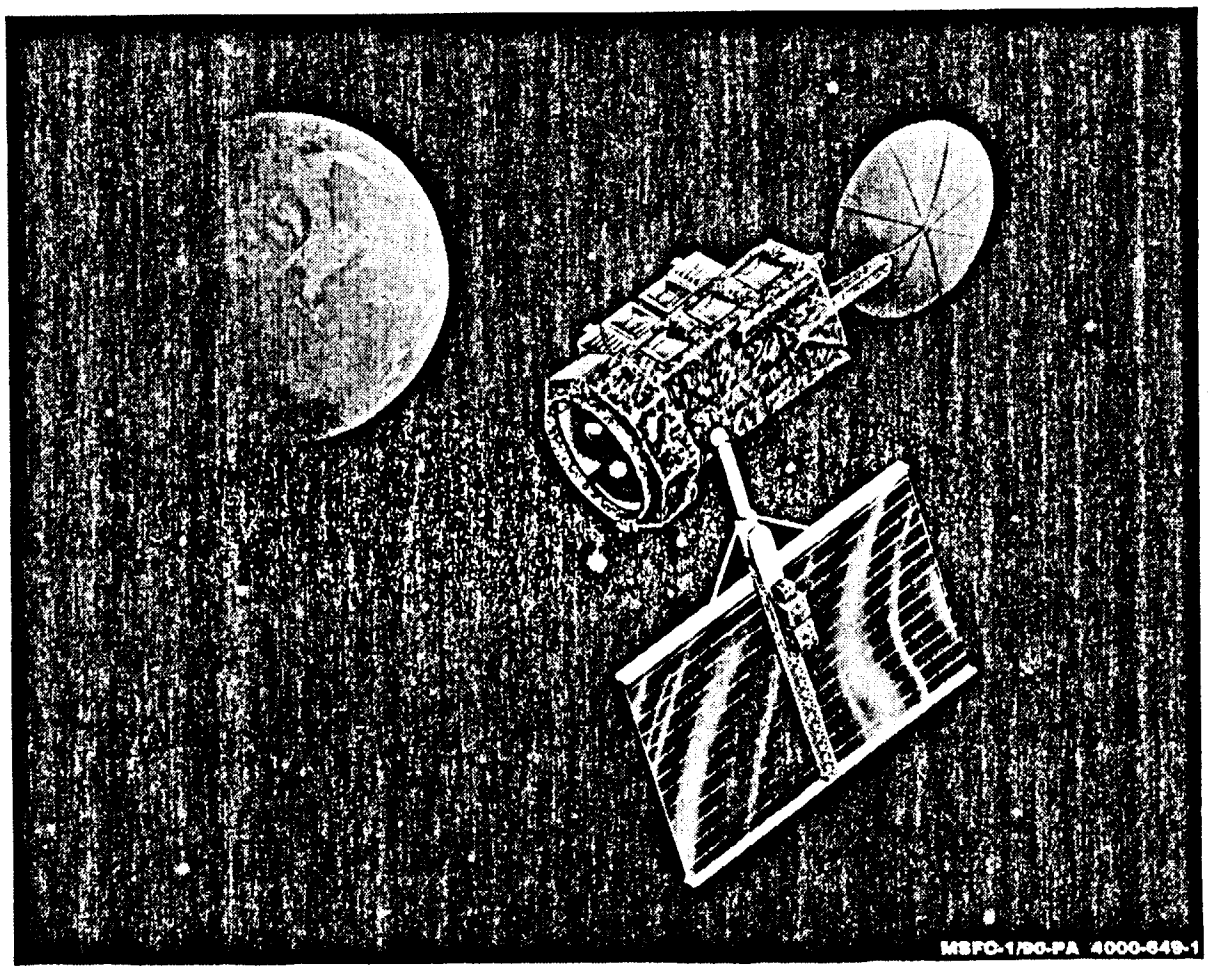
GEO permits time-continuous observations necessary for comprehensive physical and dynamical modeling of the global Earth System

Diurnal observations
Multiple image compositing
Timely observation of transient events
Long-duration sensor staring
Hemispheric coverage
Fast sequential imaging
Constant viewing angle
Varying sun angle
Continuous solar observations

Potential GEO facility instruments include:

Microwave Imager/Sounder
IR Atmospheric Profiler
Visible/IR Spectrometer (moderate resolution)
Visible/IR High-Resolution Imager
Lightning Sensor

Geostationary Earth Observatory (GEO) Mission Concept



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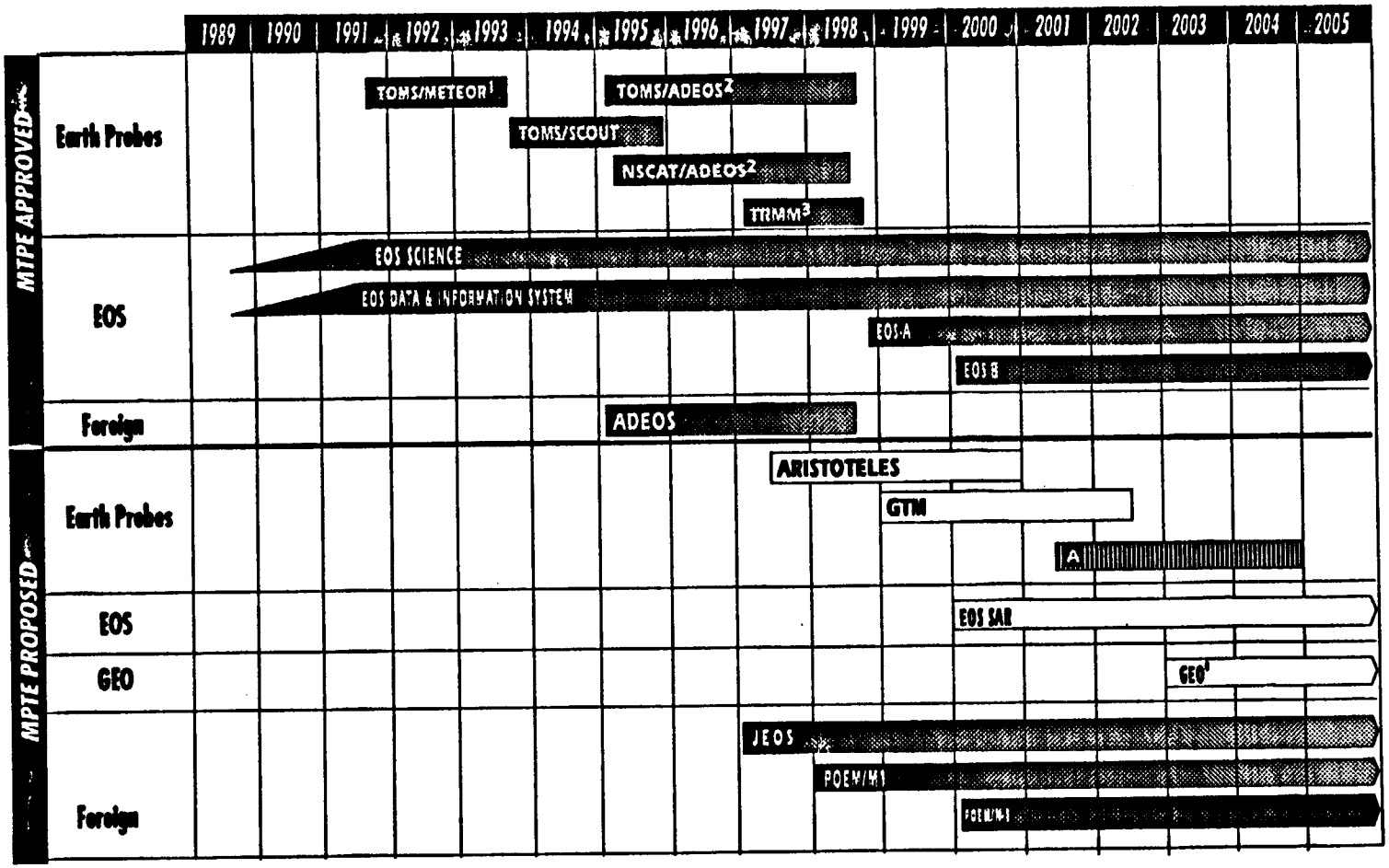
MTPE Space Assets for Global Change Studies



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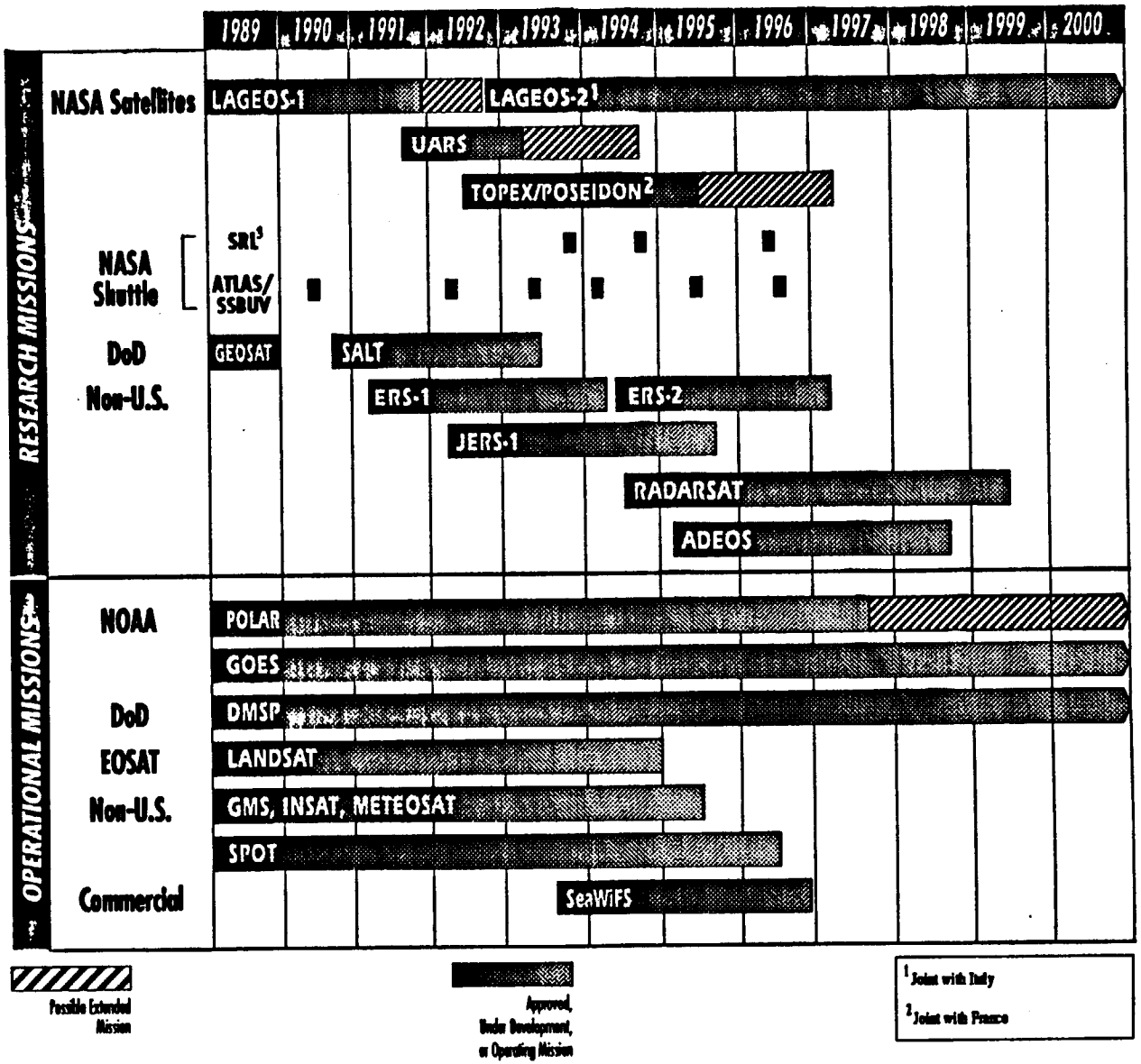
Base Program Space Assets for Global Change Studies



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